Alabama Department of Environmental Management

Draft

Nutrient Total Maximum Daily Loads (TMDLs)

for

Locust Fork

Waterbody ID AL03160111-0305-102
Waterbody ID AL03160111-0308-102
Waterbody ID AL03160111-0404-102
Waterbody ID AL03160111-0413-112
Waterbody ID AL03160111-0413-101

&

Village Creek

Waterbody ID AL03160111-0409-100

Alabama Department of Environmental Management
Water Division
Water Quality Branch
May 2017

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Useful Acronyms & Abbreviation

A

A&I - Agriculture and Industry Use Classification
AAF - Average Annual Flow
ACES - Alabama Cooperative Extension Service
ADEM - Alabama Department of Environmental Management
ADPH - Alabama Department of Public Health
AEMC - Alabama Environmental Management Commission
AFO - Animal Feeding Operation
AL - Alabama; Aluminum (Metals)
AS - Arsenic
ASWCC - Alabama Soil & Water Conservation Committee
AWIC - Alabama Water Improvement Commission

B

BAT - Best Available Technology
BCT - Best Conventional Pollutant Control Technology
BMP - Best Management Practices
BOD - Biochemical Oxygen Demand
BPJ - Best Professional Judgment

C

CAFO - Concentrated Animal Feeding Operation
$CBOD_5$ - Five-Day Carbonaceous Biochemical Oxygen Demand
$CBOD_u$ - Ultimate Carbonaceous Biochemical Oxygen Demand
CFR - Code of Federal Regulations
CFS - Cubic Feet per Second
CMP - Coastal Monitoring Program
COD - Chemical Oxygen Demand
CPP - Continuing Planning Process
CWA - Clean Water Act
CY - Calendar Year

D

DA - Drainage Area
DEM - Digital Elevation Model
DMR - Discharge Monitoring Report
DNCR - Department of Conservation & Natural Resources
DO - Dissolved Oxygen

E

EFDC – Environmental Fluid Dynamics Code

F

F&W - Fish and Wildlife Use Classification
FDA - Food and Drug Administration
Fe - Iron
FO - Field Operations
FS - Forestry Service (US)
FY - Fiscal Year

G

GIS - Geographic Information Systems
GOMA - Gulf of Mexico Alliance
GPS - Global Positioning System
GS - Growing Season
GSA - Geological Survey of Alabama

H

HCR - Hydrographic Controlled Release
Hg - Mercury
HUC - Hydrologic Unit Code

I

IBI - Index of Biotic Integrity
IF - Incremental Flow
IWC - Instream Waste Concentration

L

LA - Load Allocation
Lat/Long- Latitude / Longitude
LDC - Load Duration Curve
LIDAR - Light Detection & Ranging
LSPC - Load Simulation Program C
LWF - Limited Warmwater Fishery Use Classification

M

m^3/s - Cubic Meters per Second
MAF - Mean Annual Flow (MAF = AAF)
mg/l - Milligrams per Liter
MGD - Million Gallons per Day
mi - Miles
MOS - Margin of Safety
MS4s - Municipal Separate Storm Sewer Systems
MZ - Mixing Zone

Useful Acronyms & Abbreviation (cont)

N

N - Nitrogen
NA - Not Applicable
NASS - National Agricultural Statistics Service
$NBOD_x$ - Nitrogenous Biochemical Oxygen Demand
NED - National Elevation Database
NH_3-N - Ammonia Nitrogen
NHD - National Hydrography Database
NLCD - National Land Cover Dataset
NO_3+NO_2-N -Nitrate + Nitrite Nitrogen
NOAA - National Oceanic and Atmospheric Administration
NOV - Notice of Violation
NPDES - National Pollutant Discharge Elimination Syst
NPS - Non-Point Source
NRCS - National Resource Conservation Service
NTUs - Nephelometric Turbidity Units
NWS - National Weather Service

O

OAW – Outstanding Alabama Water Use Classification
OE - Organic Enrichment
ONRW - Outstanding National Resource Water

P

P - Phosphorus
Pb - Lead
PCBs - Polychlorinated Biphenyl
pH - Concentration of Hydrogen Ions Scale
POTW - Publicly Owned Treatment Works
ppb - Parts per Billion
ppm - Parts per Million
ppt - Parts per Trillion
PS - Point Source
PWS - Public Water Supply Use Classification
PWSS - Public Water Supply System

Q

Q - Flow (MGD, m^3/s, cfs)
QA/QC - Quality Assurance / Quality Control
QAPP - Quality Assurance Project Plan

R

RRMP - River and Reservoirs Monitoring Program
RSMP - River and Streams Monitoring Program

S

S - Swimming and Other Whole Body Waters Contact Sports Use Classification
SH - Shellfish Harvesting Use Classification

S (cont)

SID - State Indirect Discharge
SMZ - Streamside Management Zone
SOD - Sediment Oxygen Demand
SOP - Standard Operating Procedure
SRF - State Revolving Fund
SSO - Sanitary Sewer Overflow
STP - Sewage Treatment Facility
SW - Surface Water
SWMP - Stormwater Management Plan
SWQM - Spreadsheet Water Quality Model (AL)
SWQMP - Surface Water Quality Monitoring Program

T

TBC - Technology-Based Controls
TBD - To be Determined
TDS - Total Dissolved Solids
TKN - Total Kjeldahl Nitrogen
TMDL - Total Maximum Daily Load
TON - Total Organic Nitrogen
TOT - Time of Travel
Total P - Total Phosphorus
TSS - Total Suspended Solids
TVA - Tennessee Valley Authority

U

UAA - Use Attainability Analysis
UIC - Underground Injection Control
USDA - United Stated Department of Agriculture
USGS - United States Geological Survey
USEPA - United States Environmental Protection Agency
USFWS - United States Fish & Wildlife Services
UT - Unnamed Tributary
UV - Ultraviolet Radiation

W

WASP - Water Quality Analysis Simulation Program
WCS - Watershed Characterization System
WET - Whole Effluent Toxicity
WLA - Wasteload Allocation
WMA - Wildlife Management Area
WPCP - Wastewater Pollution Control Plant
WQB - Water Quality Branch
WRDB - Water Resources Database
WTP - Water Treatment Plant
WWTF - Wastewater Treatment Facility
WWTP - Wastewater Treatment Plant
WY - Water Year

Chapter 1. Introduction

1.1. Executive Summary

The purpose of this report is to address the nutrient impairment on the Locust Fork, a major tributary to the Black Warrior River located in central Alabama. The report will also address the nutrient impairment on Village Creek, a tributary to the Locust Fork located west of Birmingham. The report presents a Total Maximum Daily Load (TMDL), which establishes pollutant loads that are necessary to attain the applicable water quality standards and are protective of the designated uses of the Locust Fork and Village Creek.

The Locust Fork was originally added by the U.S. Environmental Protection Agency (USEPA) to Alabama's §303(d) List of Impaired Waterbodies in 1998 with nutrients listed as the pollutant of concern. The EPA's addition of this impaired segment of the Locust Fork was based upon a review of federally threatened and endangered species data published by the U.S. Fish and Wildlife Service (USFWS) in 1996. At the time of the EPA's inclusion of the Locust Fork on the 1998 §303(d) List, the impaired reach was considered to be one single 47.3 mile segment, from County Rd 77 upstream to the mouth of Little Warrior River. In 2004, the impaired reach of the Locust Fork was re-segmented from one segment, formerly representing the entire impaired reach, to three individual segments in order to accurately depict the designated use classification of each individual segment. In 2012, the Department identified two additional segments of the Locust Fork that are impaired for nutrients and therefore added those segments to the 2012 §303(d) list. The listings were based on an analysis of water quality data collected at the Department's reservoir stations located on those impaired reaches from 2005-2011.

In 2012, the Department also identified one segment of Village Creek as being impaired for nutrients and therefore added the segment to the 2012 §303(d) list. The listing was based upon an analysis of water quality data collected during the time frame of 2005 to 2011 at station VLGJ-5 located on the impaired reach.

In the non-wadeable tributary embayment segment of the Locust Fork, those conditions that facilitate the uptake of available nutrients in the water column, such as longer retention times and greater available sunlight reaching the water surface leading to increased water temperatures, are greatly improved compared to the wadeable segments. Consequently, the negative effects associated with the elevated concentrations of nutrients observed in the wadeable riverine segments of the Locust Fork, and several major tributaries to the Locust Fork, are being expressed further downstream in the tributary embayment lake segments. Therefore, the Department will establish the TMDL endpoint, in this case a chlorophyll-a target concentration, in the tributary embayment lake segment at existing station BANT-3. The chlorophyll-a growing season average target of 18 µg/L will be considered protective of the designated uses of both the tributary embayment and also the mainstem wadeable segments located upstream in the watershed.

The implementation of the point source nutrient reductions necessary to meet the instream chlorophyll-a target will be applicable to all continuous point sources located throughout the watershed that contribute to the nutrient impairment, and not just those sources that discharge directly to the mainstem Locust Fork. Moreover, the nutrient reductions in the Village Creek watershed as a result of this TMDL indicate the established chlorophyll-a target in the Locust Fork tributary embayment will also be considered protective of the designated uses of the lower Village Creek segment. Therefore, this TMDL also addresses the lower segment of Village Creek that was added to Alabama's §303(d) List of Impaired Waterbodies in 2012 with nutrients listed as the pollutant of concern.

The TMDL development process utilized a series of dynamically linked water quality models (LSPC, EFDC, and WASP) to accurately predict the necessary nutrient reductions in the watershed to meet the established chlorophyll-a target. The three individual modeling programs were executed to dynamically simulate the time period from January 1, 2007 to December 31, 2012. The model network was calibrated based upon available metrological, hydrological, and ambient water quality data during the model simulation period.

The final TMDL is based upon the necessary waste load allocation (WLA), load allocation (LA), and margin of safety (MOS) required to meet a numeric chlorophyll-a growing season average target of 18 µg/l, established at the compliance point located in the Locust Fork tributary embayment at station BANT-3. The waste load allocation component for the continuous point sources in the Locust Fork watershed should be applied as an effluent monthly average total phosphorus concentration limit applicable during the months of March through October.

Table 1.1 Locust Fork and Village Creek Nutrient TMDL

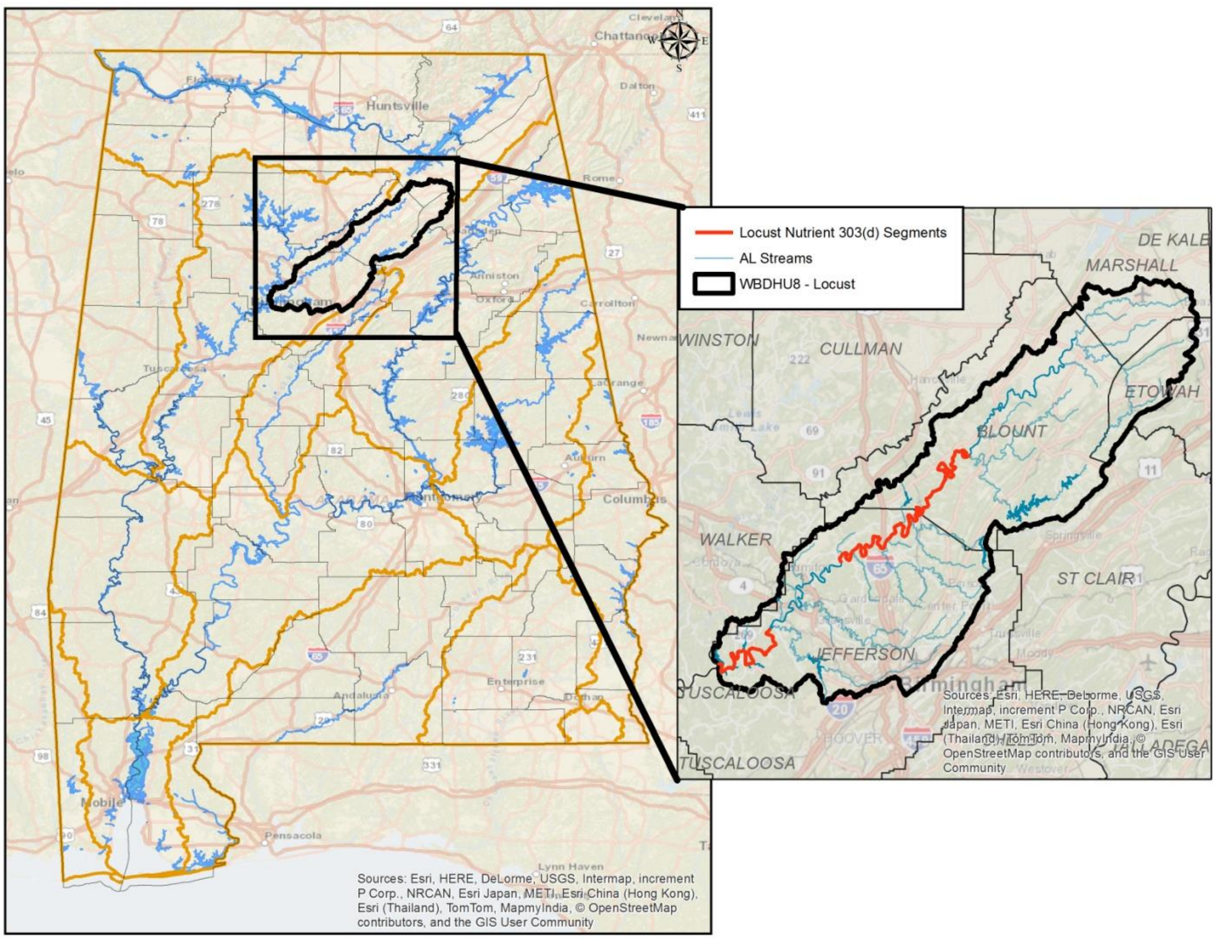
WLA (Continuous Sources)			WLA (MS4 Stormwater Sources)	LA (Stormwater Sources)	Margin of Safety
TP Effluent Limit for Class 1 (Qw ≥ 1 MGD)	TP Effluent Limit for Class 2 (Qw < 1 MGD & Qw ≥ 0.1 MGD)	TP Effluent Limit for Class 3 (Qw < 0.1 MGD)	Percent Reduction to existing TP Load	Percent Reduction to existing TP Load	
0.25 mg/L	2 mg/L	6 mg/L	36% [a]	36%	Implicit

a. MS4 permits that are located in the Locust Fork Watershed must comply with this TMDL. MS4 permits are BMP-based and currently do not specify numeric total phosphorus limits. Therefore, TMDL compliance will be demonstrated through implementation and maintenance of BMPs on a case-by-case basis. For the purposes of this TMDL, the 36% reduction to existing MS4 Stormwater Source total phosphorus loads should not be interpreted as a numeric permit limitation.

1.2 Locust Fork Background Information

The Locust Fork is a major tributary to the Black Warrior River. The Locust Fork watershed is primarily located in Jefferson and Blount counties, although the north-eastern headwater extent also resides in Marshall and Etowah counties. The Locust Fork flows southwest for a total stream length of 160 miles before its confluence with the Mulberry Fork in Bankhead Lake Reservoir. The total watershed drainage area is approximately 1209 square miles. The Locust Fork is the second longest free-flowing river in Alabama and as such the river has garnished the reputation for being a premiere whitewater destination in the Southeast.

Figure 1.2.1 Locust Fork Watershed Location



The Department has assigned designated uses for all the assessed waterbodies found in the Locust Fork Watershed. Designated uses describe the best uses that can be reasonably expected for those particular waters. The mainstem of the Locust Fork includes the following designated uses: Public Water Supply (PWS), Swimming (S), and Fish and Wildlife (F&W). The highlighted segments in red shown below have been placed in Category 5 and listed on the Department's §303(d) List, meaning those particular segments are considered impaired and are consequently not meeting their designated use classifications.

Figure 1.2.2 Locust Fork Watershed – Waterbody Designated Uses and 2016 §303(d) Segments

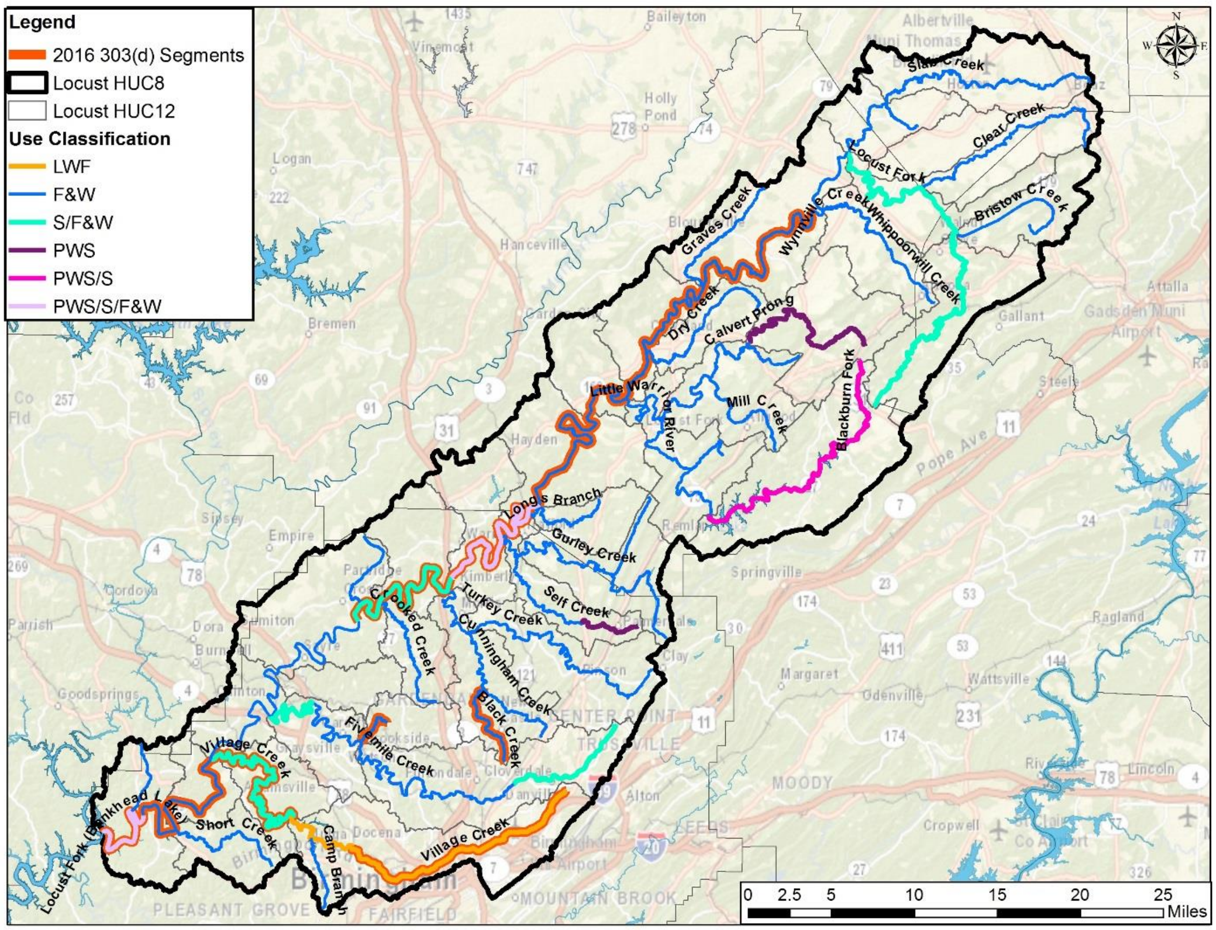


Table 1.2.1 on the following page provides additional information for all of the assessed waterbodies in the Locust Fork watershed, including the 2016 assessment unit, use classification, and waterbody category.

Table 1.2.1 Locust Fork Watershed – Waterbody Designated Uses and Categories

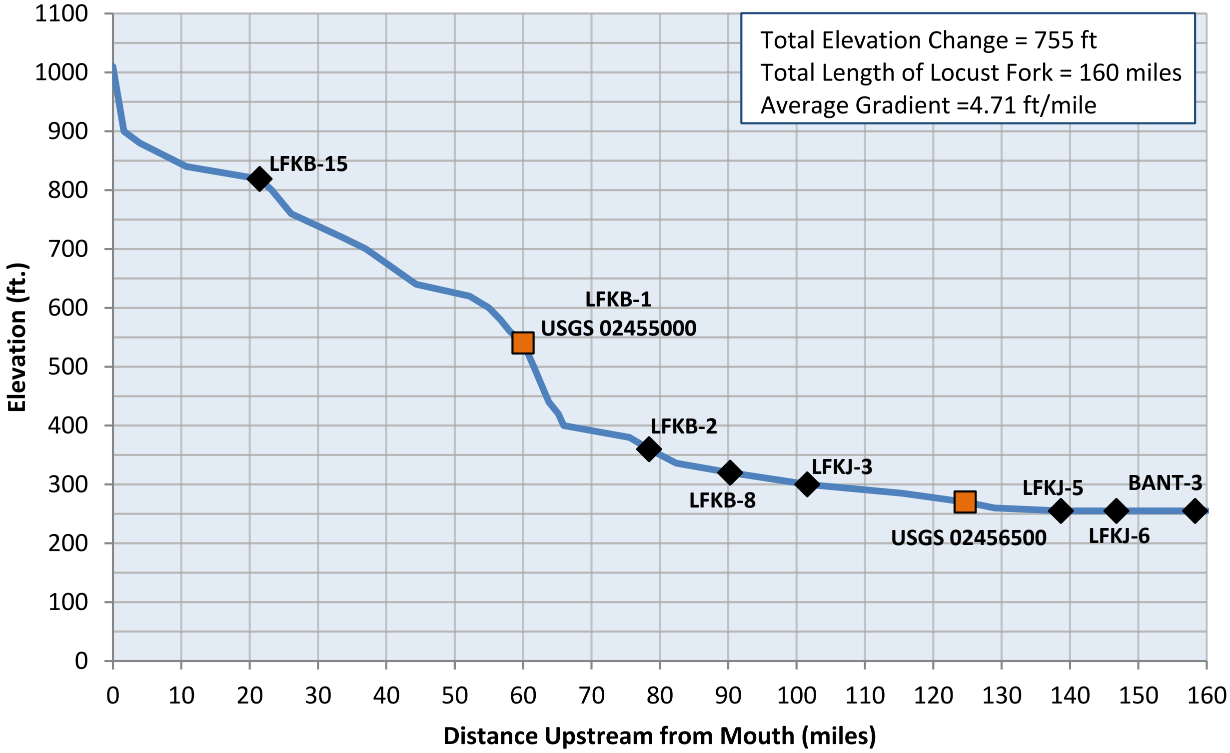
2016 ASSESSMENT ID	WATERBODY	USE CLASS	DOWNSTREAM EXTENT	UPSTREAM EXTENT	CATE-GORY
AL03160111-0307-400	Black Creek	F&W	Cunningham Creek	its source	5
AL03160111-0204-111	Blackburn Fork	PWS	Inland Lake Dam	extent of reservoir	1
AL03160111-0204-102	Blackburn Fork	PWS	Inland Lake	Highland Lake Dam	1
AL03160111-0204-103	Blackburn Fork	PWS	Highland Lake Dam	extent of reservoir	1
AL03160111-0204-104	Blackburn Fork	PWS	Highland Lake	Its source	1
AL03160111-0207-300	Blackburn Fork	F&W	Little Warrior River	Inland Lake Dam	1
AL03160111-0101-100	Bristow Creek	F&W	Locust Fork	Its source	2B
AL03160111-0206-101	Calvert Prong	F&W	Little Warrior River	Whited Creek	1
AL03160111-0206-102	Calvert Prong	PWS	Whited Creek	Its source	1
AL03160111-0408-300	Camp Branch	F&W	Bayview Lake	Its source	4A
AL03160111-0206-500	Chitwood Creek	F&W	Calvert Prong	Its source	3
AL03160111-0103-100	Clear Creek	F&W	Locust Fork	Its source	2B
AL03160111-0413-600	Coal Creek	F&W	Locust Fork	its source	2A
AL03160111-0401-100	Crooked Creek	F&W	Locust Fork	Its source	2B
AL03160111-0307-200	Cunningham Creek	F&W	Turkey Creek	Its source	3
AL03160111-0203-100	Dry Creek	F&W	Locust Fork	Its source	5
AL03160111-0407-100	Fivemile Creek	F&W	Locust Fork	Its source	4B
AL03160111-0202-200	Graves Creek	F&W	Locust Fork	Its source	4A
AL03160111-0304-100	Gurley Creek	F&W	Locust Fork	Its source	1
AL03160111-0207-900	Hendrick Mill Branch	F&W	Blackburn Fork	Its source	1
AL03160111-0106-110	Little Reedbrake Creek	F&W	Slab Creek	Its source	2B
AL03160111-0207-100	Little Warrior River	F&W	Locust Fork	Its source	1
AL03160111-0202-102	Locust Fork	F&W	Blount County Road 30	Its source	1
AL03160111-0413-101	Locust Fork	PWS/S / F&W	Junction of Locust and Mulberry Forks	Jefferson County Highway 61	5
AL03160111-0410-100	Locust Fork	F&W	Village Creek	Jefferson County Road 77	2B
AL03160111-0208-101	Locust Fork	F&W	Little Warrior River	Blount County Road 30	5
AL03160111-0305-102	Locust Fork	F&W	County road between Hayden and County Line	Little Warrior River	5
AL03160111-0308-102	Locust Fork	PWS/ F&W	US Highway 31	county road between Hayden and County Line	5
AL03160111-0404-102	Locust Fork	F&W	Jefferson County Road 77	US Highway 31	5
AL03160111-0413-112	Locust Fork	F&W	Jefferson County Highway 61	Village Creek	5
AL03160111-0302-100	Longs Branch	F&W	Locust Fork	Its source	2A
AL03160111-0206-800	Mill Creek	F&W	Chitwood Creek	Its source	3
AL03160111-0405-101	Newfound Creek	F&W	Fivemile Creek	Impoundment	5
AL03160111-0303-200	Sand Valley Creek	F&W	Gurley Creek	Its source	2B
AL03160111-0304-201	Self Creek	F&W	Gurley Creek	Alabama Highway 79	2B
AL03160111-0304-202	Self Creek	PWS	Alabama Highway 79	Its source	2B
AL03160111-0411-100	Short Creek	F&W	Locust Fork	Its source	1
AL03160111-0106-100	Slab Creek	F&W	Locust Fork	Its source	2B
AL03160111-0307-100	Turkey Creek	F&W	Locust Fork	Its source	2A
AL03160111-0409-100	Village Creek	F&W	Locust Fork	Bayview Lake Dam	5
AL03160111-0408-101	Village Creek	LWF	Bayview Lake Dam	Second Creek	4A
AL03160111-0408-102	Village Creek	LWF	Second Creek	Woodlawn Bridge	5
AL03160111-0408-103	Village Creek	LWF	Woodlawn Bridge	Its source	5
AL03160111-0404-500	Ward Creek	F&W	Locust Fork	Its source	2B
AL03160111-0201-600	Whippoorwill Creek	F&W	Wynnville Creek	Its source	3
AL03160111-0206-700	Whited Creek	F&W	Calvert Prong	Its source	3
AL03160111-0201-100	Wynnville Creek	F&W	Locust Fork	Its source	2B

1.2.1 Hydrology

The physical properties of the Locust Fork, including the diversity of habitat, benthic substrate, and channel shape, all vary significantly depending on the location in the watershed. The headwater sections of the Locust Fork are generally characterized by riffle-run habitat type and the dominate substrate consists primarily of gravel with some boulder and cobble. Progressing downstream, the habitat type transitions to a glide-pool type stream and the dominant benthic substrate consists primarily of sand, with some gravel.

Downstream of US Highway 78 (rivermile 135 in the graph below), the Locust Fork transitions to a mature first or second order river with a lower gradient (slope) and generally a slower ambient velocity. The Bankhead reservoir heavily influences the hydrodynamic conditions (discharge, stage height, and velocity) of the downstream 30 miles of the Locust Fork.

Figure 1.2.1.1 Locust Fork Elevation Gradient



Currently, there are twelve realtime USGS streamflow stations actively monitoring streamflow on six different waterbodies in the Locust Fork watershed. Two realtime active USGS streamflow stations are located directly on the mainstem of the Locust Fork. The following pages illustrate the location of the USGS streamflow stations in the watershed, along with accompanying stream low flow statistics and flow duration curves for the USGS stations located directly on the Locust Fork.

Table 1.2.1.1 Realtime USGS Stream Gages in Locust Fork Watershed

Agency	Site Number	Site Name
USGS	02455000	LOCUST FORK NEAR CLEVELAND, AL.
USGS	02455185	BLACKBURN FORK LITTLE WARRIOR R NR HOLLY SPRINGS
USGS	02455980	TURKEY CREEK AT SEWAGE PLANT NEAR PINSON AL
USGS	02456500	LOCUST FORK AT SAYRE, AL.
USGS	02457000	FIVEMILE CREEK AT KETONA AL
USGS	02457595	FIVEMILE CREEK NEAR REPUBLIC, AL
USGS	02458148	VILLAGE CREEK AT 86TH ST NORTH AT ROEBUCK, AL.
USGS	02458190	TRIB TO VILLAGE CREEK AT 50th ST IN BIRMINGHAM
USGS	02458300	VILLAGE CREEK AT 24TH ST. AT BIRMINGHAM, AL
USGS	02458450	VILLAGE CREEK AT AVENUE W AT ENSLEY, AL
USGS	02458502	VILLAGE CREEK NEAR PRATT CITY, ALABAMA
USGS	02458600	VILLAGE CREEK NEAR DOCENA, ALABAMA

Figure 1.2.1.2 Location of Realtime USGS Stream Flow Gages in Locust Fork Watershed

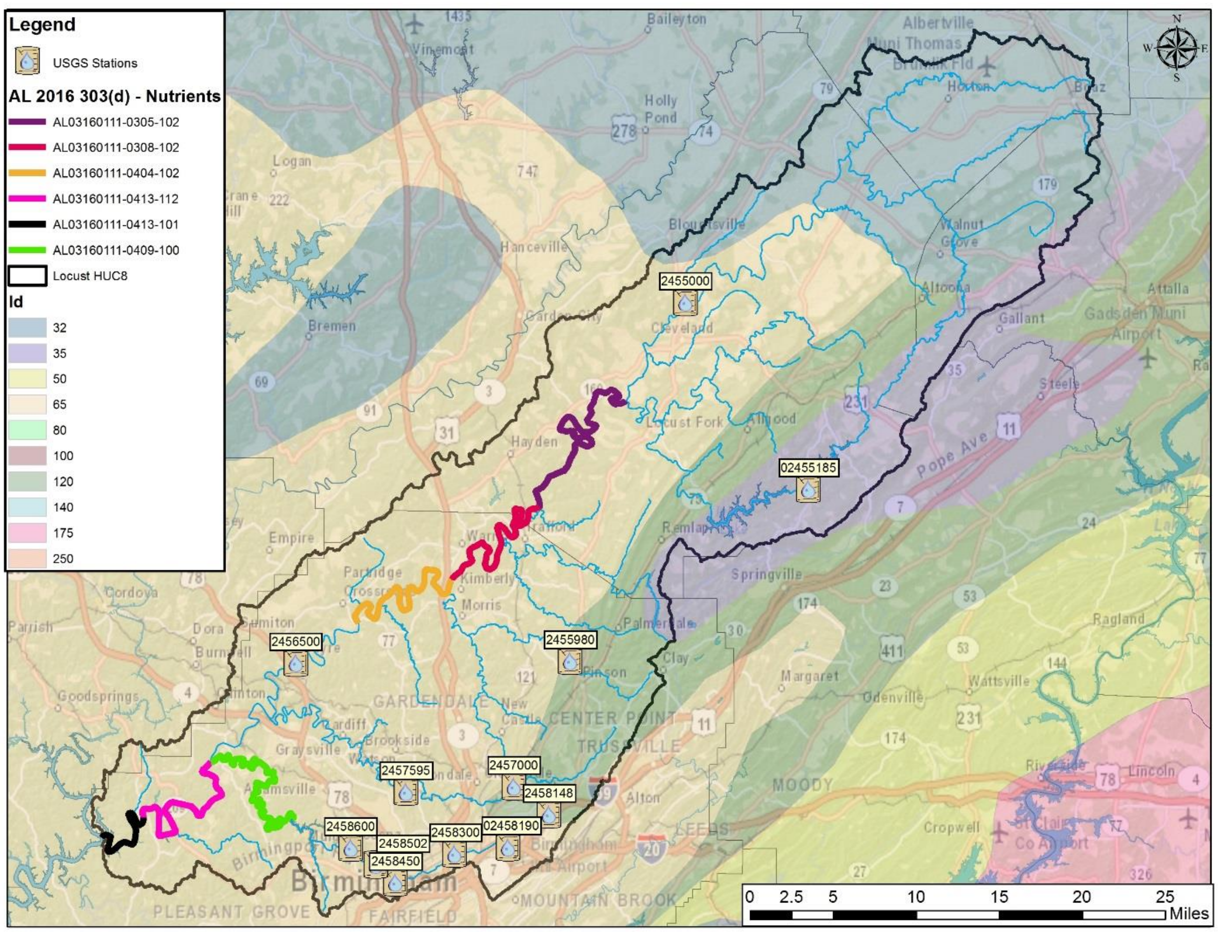
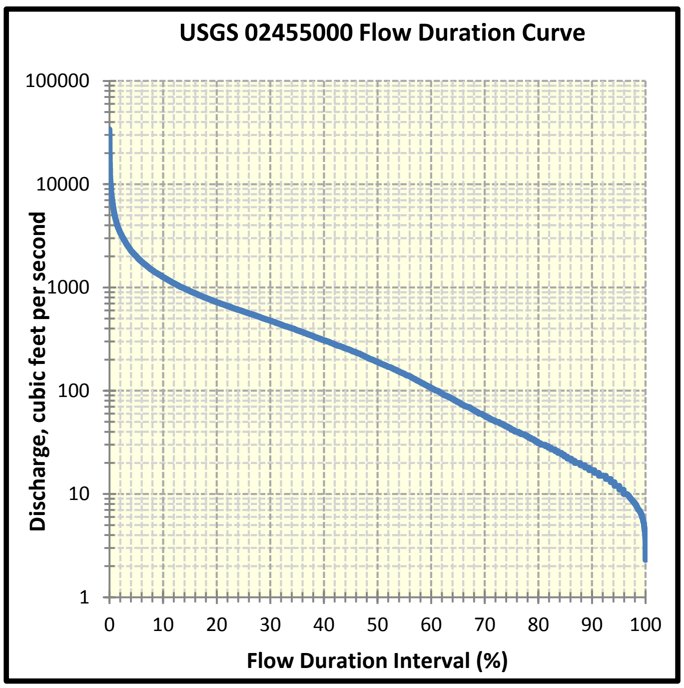
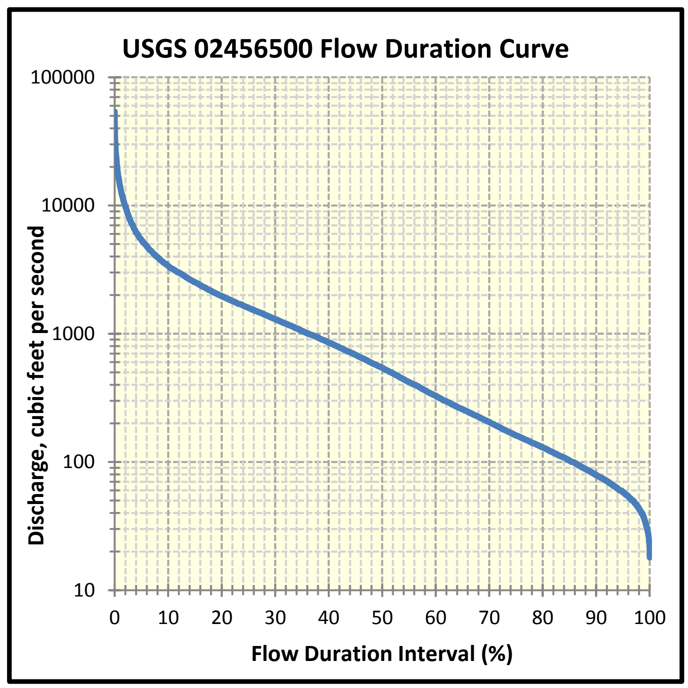


Figure 1.2.1.3 Locust Fork USGS Gage Low Flow Statistics

Name	Locust Fork Near Cleveland, AL.
USGS Gage #	02455000
Period of Record	12/01/1936 to 5/31/2016
Coordinates	34.0244, -86.5742
Drainage Area (mi^2):	303
7Q10 (cfs):	5.68
7Q2 (cfs):	12.28
1Q10 (cfs):	5.12

Name	Locust Fork at Sayre, AL
USGS Gage #	02456500
Period of Record	10/01/1928 to 9/30/2016
Coordinates	33.7097,-86.9833
Drainage Area (mi^2):	885
7Q10 (cfs):	31.12
7Q2 (cfs):	58.19
1Q10 (cfs):	27.82

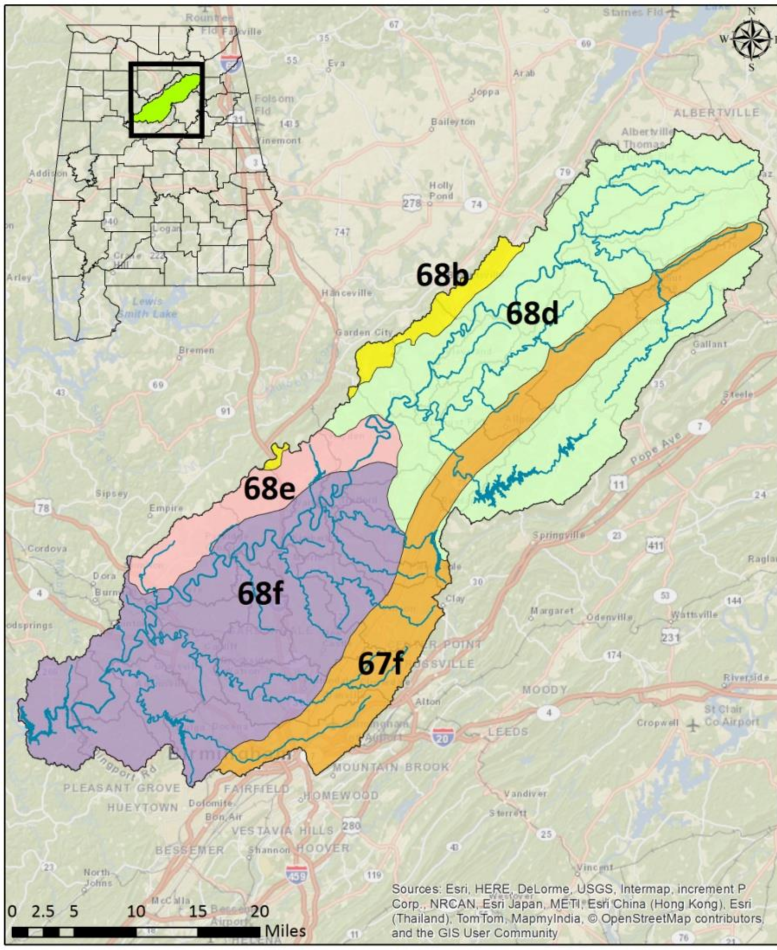




1.2.2 Eco-Regions

The Locust Fork watershed is comprised of two Level III Ecoregions: 67-Ridge and Valley and 68-Southwestern Appalachians. The watershed can be further subdivided into the following Level IV Ecoregions: 67f Southern Limestone/Dolomite Valleys and Low Rolling Hills (17%), 68b Sequatchie Valley (2%), 68d Southern Table Plateaus (39%), 68e Dissected Plateau (7%), 68f Shale Hills (34%). The figure below illustrates the aforementioned Level IV ecoregions found in the Locust Fork Watershed and provides a brief description of each ecoregion.

Figure 1.2.2.1 Locust Fork Watershed Level IV Eco-regions



Ecoregion	Ecoregion Description
67f	The **Southern Limestone/Dolomite Valleys and Low Rolling Hills** form a heterogeneous region composed predominantly of limestone and cherty dolomite. Landforms are mostly undulating valleys and rounded ridges and hills, with many caves and springs. Soils vary in their productivity, and land cover includes oak-hickory and oak-pine forests, pasture, intensiveagriculture, and urban and industrial. Along the Coosa River floodplain, biota more typical of coastal plain regions can be found due to the valley and riverine connection to ecoregion 65 in Alabama.
68b	From the Tennessee border, the elongated **Sequatchie Valley** extends nearly one hundred miles southwest into Alabama. Structurally associated with an anticline, where erosion of broken rock scooped out the linear valley, it is composed mostly of Mississippian to Ordovician-age limestones, dolomites, and shales, with some low, cherty ridges. In the north, the open, rolling, valley floor, 600 feet in elevation, is nearly 1000 feet below the top of the Cumberland Plateau and Sand Mountain. South of Blountsville, the topography becomes more hilly and irregular with higher elevations. The Tennessee River flows through the Sequatchie Valley in Alabama, until it turns west near Guntersville and leaves the valley. Similar to parts of the Ridge and Valley, this is an agriculturally productive region, with areas of pasture, hay, soybeans, small grain, corn, and tobacco.
68d	The **Southern Table Plateaus** include Sand Mountain, Lookout Mountain, and Brindley Mountain. While it has some similarities to the Cumberland Plateau (68a) with its Pennsylvanian-age sandstone caprock, shale layers, and coal-bearing strata, this ecoregion is lower in elevation, has a slightly warmer climate, and has moreagriculture. It is at higher elevations and has more gentle topography with less dissection than the more forested ecoregions of 68e and 68f. Although the Georgia portion is mostly forested, elevations decrease to the southwest in Alabama and there is more cropland and pasture. It is a major poultry production region in Alabama.
68e	The **Dissected Plateau** is so strongly dissected that it no longer has a typical plateau appearance. The rugged, mostly forested region contains predominantly strongly sloping land, some steep-sided gorges and sandstone cliffs, and relief of 300-400 feet. The cool canyons and valleys often contain plant and animal species usually found further north. The Bankhead National Forest occupies a large portion of 68e, providing public recreation, wilderness, and forestry areas. Most of the region is drained by the Sipsey Fork of the Black Warrior River. The Sipsey Fork is a National Wild and Scenic River in its headwaters, and downstream is impounded to form Lewis Smith Lake, a hydro-electric generating reservoir, also popular for bass fishing.
68f	The **Shale Hills** ecoregion, sometimes called the Warrior Coal Field, has more shale and less sandstone than 68e. The soils generally have silt loam surfaces rather than sandy loams and have a silty clay or clayey subsoil. Although it has the lowest elevations in ecoregion 68, the surface features are characterized by extensive hills and mostly strongly sloping topography. The shale, siltstone, and sandstone are relatively impermeable, and streams do not have the base flow found in more permeable adjacent areas, such as 65i or 67f. The region is mostly forested, but coal mining is a major industry, and the extensive open-pit mines have altered the landscape, soils, and streams.

1.2.3 Environmental Importance

As previously discussed, the Locust Fork is a valuable natural resource within the state of Alabama. The waterbody provides numerous benefits to the residents of Alabama including, but not limited to, the following:

- Swimming and other water sports
- Outdoor recreational activities including fishing, canoeing, and whitewater rafting
- Available pollutant assimilation from point sources located throughout the watershed

Furthermore, the Locust Fork watershed also supports a tremendously diverse population of aquatic flora and fauna. A partnership effort involving the U.S. Fish and Wildlife Service (USFWS), Alabama Department of Conservation and Natural Resources (ADCNR) and the Geological Survey of Alabama (GSA) have identified the Locust Fork watershed as critical habitat for several threatened and endangered species of fish, snails, and mussels. The table below lists the aquatic fauna currently identified by the U.S. Fish and Wildlife Service (USFWS) as being threatened or endangered that are found in the Locust Fork watershed.

Table 1.2.3.1 Threatened & Endangered Fauna in Locust Fork Watershed

Scientific name	Common name	Species	USFWS Conservation Status	Alabama Conservation Concern
Elliptio arca	Alabama Spike	Mussel		P1
Elliptio arctata	Delicate Spike	Mussel		P2
Hamiota perovalis	Orangenacre Mucket	Mussel	Threatened	P2
Medionidus acutissimus	Alabama Moccasinshell	Mussel	Threatened	P1
Medionidus parvulus	Coosa Moccasinshell	Mussel	Endangered	P1
Pleurobema furvum	Dark Pigtoe	Mussel	Endangered	P1
Ptychobranchus greenii	Triangular Kidneyshell	Mussel	Endangered	P1
Elimia melanoides	Black Mudalia	Snail	Candidate	P2
Fontigens nickliniana	Watercress Snail	Snail		P1
Leptoxis plicata	Plicate Rocksnail	Snail	Endangered	P1
Etheostoma bellator	Warrior Darter	Fish		P2
Etheostoma chermocki	Vermillion Darter	Fish	Endangered	P1
Etheostoma nuchale	Watercress Darter	Fish	Endangered	P1
Etheostoma phytophilum	Rush Darter	Fish	Endangered	P1
Etheostoma sp cf *bellator" A"*	Locust Fork Darter	Fish		P2
Notropis cahabae	Cahaba Shiner	Fish	Endangered	P1
Percina brevicauda	Coal Darter	Fish		P2
Necturus alabamensis	Black Warrior waterdog	Salamander	Candidate	P1
Sternotherus depressus	Flattened musk turtle	Turtle	Threatened	P1

P1 – Highest Conservation Concern
P2 – High Conservation Concern

Chapter 2. Problem Definition

2.1 Sampling History

The Locust Fork and several of the major tributaries in the watershed that drain out of urbanized areas of western Birmingham have historically been exposed to excessive industrial and municipal pollution. In 1949, the Alabama Water Improvement Commission conducted an intensive survey of the water quality conditions of the Black Warrior River Basin. The survey included 34 sampling locations on waterbodies in the Locust Fork watershed. The results from this sampling effort indicated several of the major tributaries to the Locust Fork that drain out of the metropolitan western Birmingham area were "grossly polluted." Furthermore, the survey concluded the “results of the laboratory analyses definitely show the deleterious effect of pollutional materials from the metropolitan Birmingham on the Locust Fork of the Warrior River” (AWIC 1949).

Since 1972, the passage of the Clean Water Act and the implementation of the NPDES permitting program have helped to address some of the chronic pollution problems observed in the Locust Fork watershed. However, in the past twenty years, the continuous increase in population of Jefferson and Blount counties has translated to larger capacity municipal waste water treatment plants in the watershed in order to accommodate the growing census.

There have been numerous studies conducted in the Locust Fork watershed in order to gain a better understanding of how the anthropogenic sources of pollution are affecting the instream water quality and consequently the aquatic life. Specifically, Fivemile Creek and Village Creek have been routinely sampled under ADEM’s Ambient Monitoring Program since the 1970’s in order to monitor the effects of the industrial and municipal point source discharges in the watersheds.

In 1997, the Environmental Indicator Section of the Field Operations Division of ADEM conducted a basin wide screening assessment of the Black Warrior River watershed. The goal of the screening project was to provide data that will allow ADEM to estimate the current status of the ecological conditions throughout the sub-basin using indicators of biological, habitat, and chemical/physical conditions. The project included an assessment of the fish and macro-invertebrate communities at a total of 43 stations located throughout the watershed. The results indicated that, of the 43 bioassessments conducted at 43 stations, only one station was assessed as “unimpaired” (3%). Seven stations (16%) were evaluated as “slightly impaired” and thirty-one stations (72%) were evaluated as “moderately impaired.” Four stations (9%) were evaluated as “severely impaired” (EIS 1999).

During 2012, the Department conducted an intensive sampling effort on the Locust Fork in order to collect water quality data that would be utilized for future TMDL development. In-situ field parameter measurements and water quality samples were collected at seven stations on a monthly basis from April – November. Also, benthic macroinvertebrate communities were sampled at five locations along the wadeable segments of the Locust Fork. The results of this monitoring effort are discussed in greater detail later in this report.

As part of the Department’s Surface Water Monitoring Strategy, a comprehensive network of fixed long term trends stations are routinely monitored on several waterbodies located within the Locust Fork watershed. The overall goal of the Department’s trend station network is to gather sufficient water quality data at specific locations so that long-term trends in water quality can be identified. Currently, there are six trend monitoring stations located on three different waterbodies in the Locust Fork Watershed. The table below gives further information in regards to the specific locations of the trend stations in addition to the scheduled sampling frequency.

Table 2.1.1 ADEM Trend Stations in Locust Fork Watershed

Station	Latitude	Longitude	Waterbody	Station Description	Sampling Frequency
FM-2	33.61111	-86.88556	Five Mile Creek	Five Mile Creek @ Republic Rd. (Cnty Rd. 67)	May/July/ September
FMCJ-1B	33.60191	-86.75527	Five Mile Creek	Five Mile Creek @ State Highway 79 (near Ketona)	May/July/ September
LFKB-1	34.02369	-86.57333	Locust Fork	Locust Fork @ ALA HWY 231	May/July/ September
LFKJ-6	33.58726	-87.10933	Locust Fork	Locust Fork of Black Warrior River @ State Highway 269	Monthly
VI-3	33.54797	-86.92567	Village Creek	Village Creek @ Jefferson County Rd. 65	May/July/ September
VLGJ-5	33.62729	-87.05334	Village Creek	Village Creek @ Jefferson County Rd. 45 (Porter Rd.)	Monthly

2.2 §303(d) List History

Section 303(d) of the Clean Water Act (CWA), as amended by the Water Quality Act of 1987, and EPA's Water Quality Planning and Management Regulations [Title 40 of the Code of Federal Regulations (CFR), Part 130] require states to identify waterbodies which are not meeting water quality standards applicable to their designated uses and to determine the total maximum daily load (TMDL) for pollutants causing use impairment. The TMDL process establishes the allowable loading of pollutants for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water-quality based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources (USEPA, 1991). The goal of the Locust Fork and Village Creek Nutrient TMDL is to establish pollutant loads that are necessary to attain the applicable water quality standards and are protective of the designated uses of both the Locust Fork and Village Creek.

2.2.1 Locust Fork §303(d) Listing History

The Alabama Department of Environmental Management (ADEM) has identified five segments of the Locust Fork of the Black Warrior River Basin as being impaired for nutrients. The table below is an excerpt from the Department's 2016 §303(d) list providing additional information about the listed segments impaired for nutrients on the Locust Fork. Refer to "Figure 3.2.1 Locust Fork 2012 §303(d) Monitoring Project Stations" for a map depicting the relative location of the impaired reaches in the watershed.

Table 2.2.1.1 Locust Fork Nutrient Impaired Segments on Department's 2016 §303(d) List

Assessment Unit ID	County	Uses	Size (miles/ acres)	Date of Data	Downstream/Upstream Locations	Year Listed
AL03160111-0305-102[a]	Blount/ Jefferson	F&W	18.15 mi	1998	County Rd between Hayden and County Line / Little Warrior River	1998
AL03160111-0308-102[a]	Blount/ Jefferson	PWS/ F&W	14.86 mi	1998	US Highway 31 / County Rd between Hayden and County Line	1998
AL03160111-0404-102[a]	Blount/ Jefferson	F&W	14.25 mi	1998	Jefferson County Rd 77 / US Highway 31	1998
AL03160111-0413-112	Jefferson	F&W	426.66 acres	2005 - 2012	Jefferson County Hwy 61 / Village Creek	2012
AL03160111-0413-101	Jefferson	PWS/S/ F&W	625.96 acres	2005 - 2012	Junction of Locust and Mulberry Fork / Jefferson County Hwy 61	2012

a. EPA addition to Department's 1998 303(d) List – 1998 ADEM Assessment Unit ID: AL/03160111-120_01

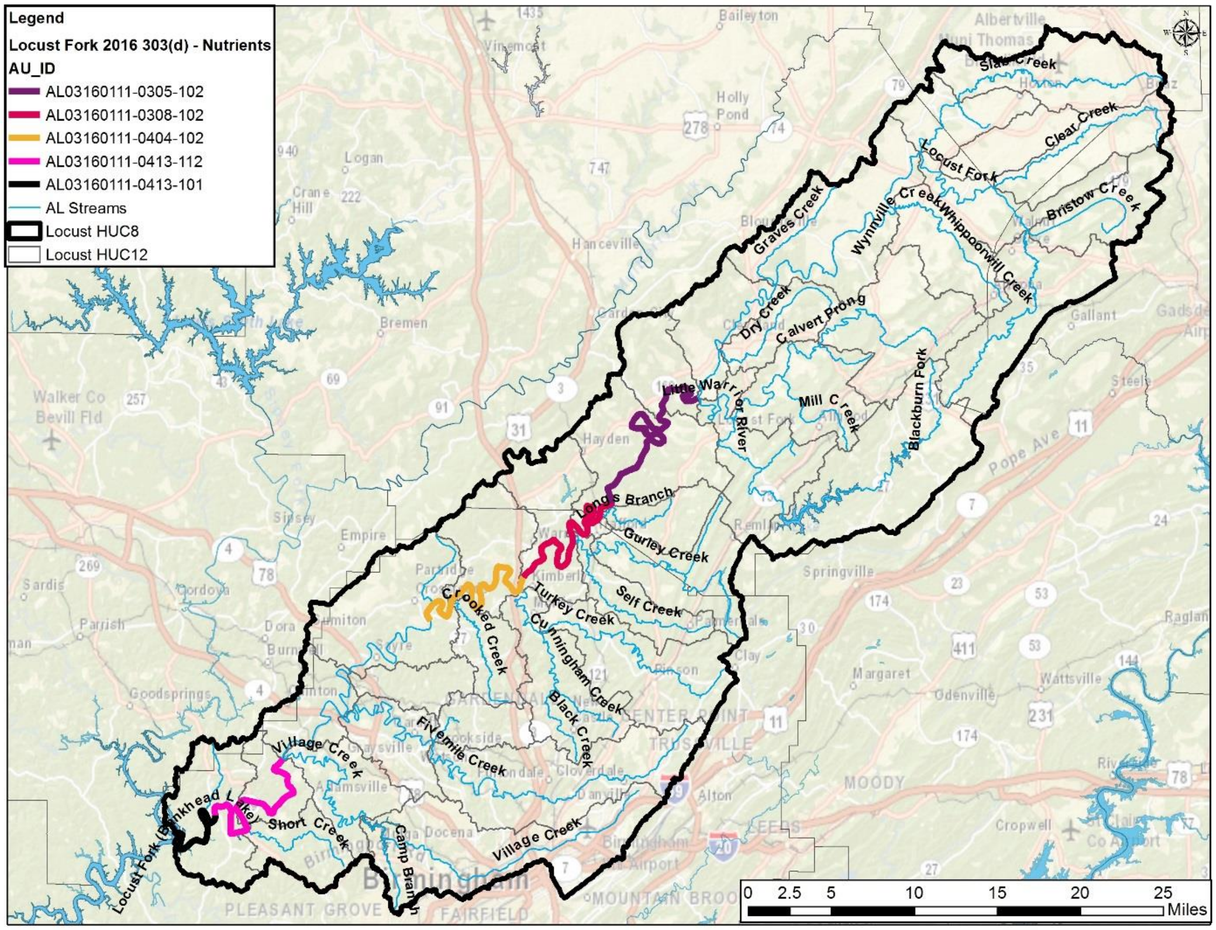
The Locust Fork was originally added by the U.S. Environmental Protection Agency (USEPA) to Alabama's §303(d) list in 1998 with nutrients listed as the pollutant of concern. The EPA's addition of this impaired segment of the Locust Fork was based upon a review of federally threatened and endangered species data published by the U.S. Fish and Wildlife Service (FWS) in 1996. The EPA coupled this information with subwatershed species occurrence data provided by both the Nature Conservancy and Alabama Natural Heritage Program (ANHP). The EPA reached the conclusion that this segment of the Locust Fork "no longer supported" its use classification due to a nutrient impairment which had consequently led to the extirpation of the federally endangered Plicate Rocksnail (*Leptoxis plicata)* formerly found in the watershed.

At the time of the Department's inclusion of the Locust Fork on the 1998 §303(d) List, the impaired reach was considered to be one single 47.3 mile segment, from County Rd 77 upstream to the mouth of Little Warrior River. In 2004, the impaired reach of the Locust Fork was re-segmented from one segment, formerly representing the entire impaired reach, to three individual segments in order to accurately depict the designated use classification of each individual segment.

In 2012, the Department identified two additional segments of the Locust Fork that are impaired for nutrients and therefore added those segments to the 2012 §303(d) list. The listings were based upon an analysis of water quality data collected at the Department's tributary embayment stations located on those impaired reaches from 2005-2011. For further information regarding the Department's basis for the addition of those segments to the 2012 §303(d) the list, see *Alabama's 2012 §303(d) List Fact Sheet*.

The figure below illustrates the nutrient impaired segments on the Locust Fork that are addressed in this TMDL:

Figure 2.2.1.1 Locust Fork Nutrient 2016 §303(d) Segments



2.2.2 Village Creek §303(d) Listing History

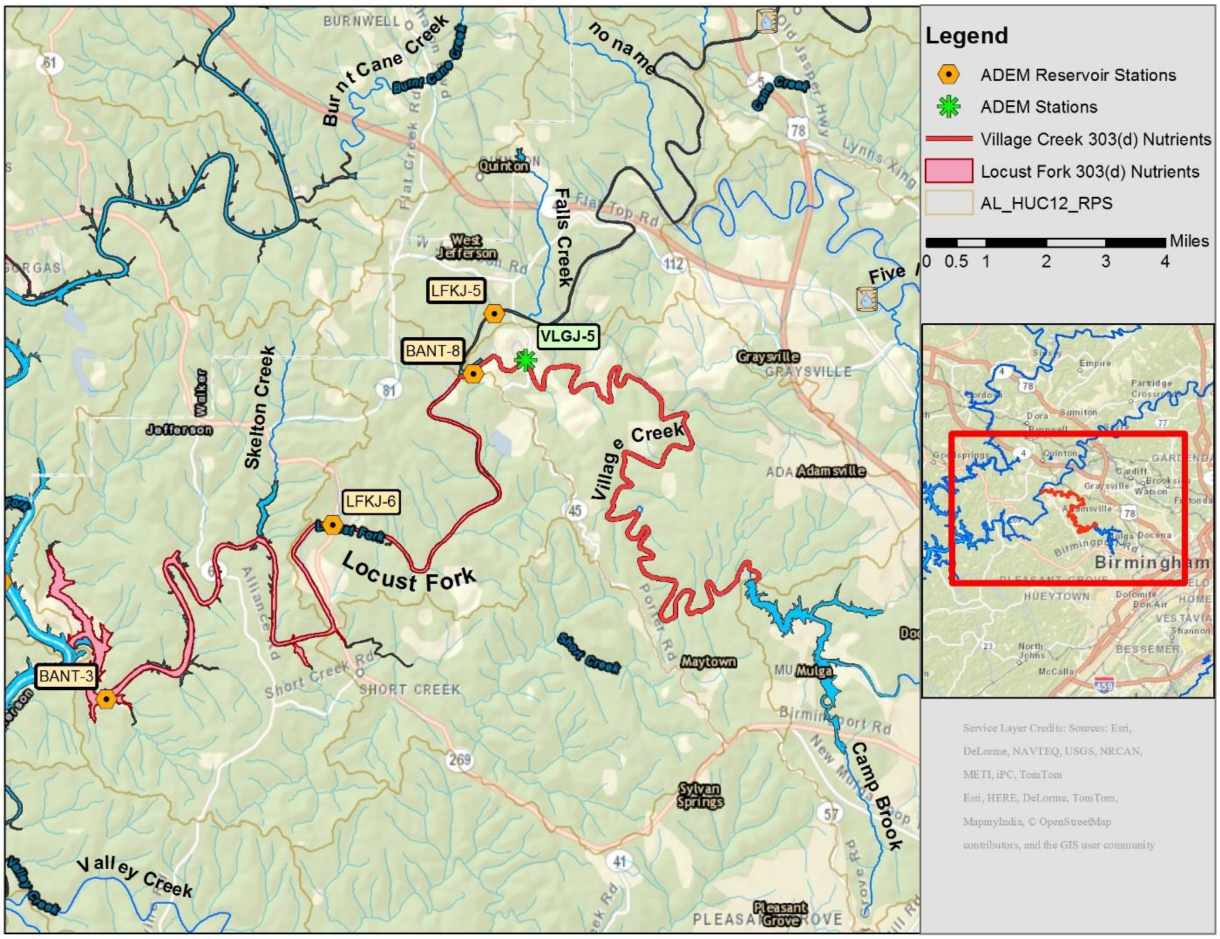
In 2012, the Department also identified one segment of Village Creek as being impaired for nutrients. The table below is an excerpt from the Department's 2016 §303(d) list providing additional information about the listed segment impaired for nutrients. The listing was based upon an analysis of water quality data collected at station VLGJ-5 from 2005-2011. For further information regarding the Department's basis for the addition of those segments to the 2012 §303(d) the list, see *Alabama's 2012 §303(d) List Fact Sheet*.

Table 2.2.2.1 Village Creek Segment on Department's 2016 §303(d) List

Assessment Unit ID	County	Use	Size (miles)	Date of Data	Downstream/Upstream Locations	Year Listed
AL03160111-0409-100	Jefferson	F&W	17.90 mi	2005-2011	Locust Fork / Bayview Lake Dam	2012

The map below illustrates the Village Creek segment (AL03160111-0409-100) that is addressed in this TMDL:

Figure 2.2.2.1 Village Creek Nutrient 2016 §303(d) Segment



2.3 Basis for Addition to §303(d) List of Impaired Waters

Based upon the available data, the Locust Fork was included on the Department's §303(d) List with nutrients and siltation considered the pollutants causing the impairment. Furthermore, Village Creek was included on the Department's §303(d) List with nutrients considered the pollutant causing the impairment. Nutrients are considered to be essential elements in the water column in regards to supporting aquatic life. However, when nutrients are present in concentrations that are considered elevated in comparison to natural conditions, there can be adverse effects such as excessive aquatic plant growth which in turn can lead to eutrophic conditions in the waterbody.

ADEM's decision to list the Locust Fork and Village Creek as being impaired for nutrients was authorized under ADEM's Water Quality Standards Program, which employs both numeric and narrative criteria to ensure adequate protection of designated uses for surface waters of the State. Numeric criteria typically have quantifiable endpoints for given parameters such as pH, dissolved oxygen, or a toxic pollutant, whereas narrative criteria are qualitative statements that establish a set of desired conditions for all State waters. These narrative criteria are more commonly referred to as “free from” criteria that enable States a regulatory avenue to address pollutants or problems that may be causing or contributing to a use impairment that otherwise cannot be evaluated against any numeric criteria. Typical pollutants that fall under this category are nutrients and siltation. Historically, in the absence of established numeric nutrient criteria, ADEM and/or EPA would use available data and information coupled with best professional judgment to determine overall use support for a given waterbody. Narrative criteria continue to serve as a basis for determining use attainability and subsequently listing/delisting of waters from Alabama’s §303(d) List. ADEM’s Narrative Criteria are shown in ADEM’s Administrative Code 335-6-10-.06 as follows:

335-6-10-.06 **Minimum Conditions Applicable to All State Waters**. *The following minimum conditions are applicable to all State waters, at all places and at all times, regardless of their uses:*

(a) State waters shall be free from substances attributable to sewage, industrial wastes or other wastes that will settle to form bottom deposits which are unsightly, putrescent or interfere directly or indirectly with any classified water use.

(b) State waters shall be free from floating debris, oil, scum, and other floating materials attributable to sewage, industrial wastes or other wastes in amounts sufficient to be unsightly or interfere directly or indirectly with any classified water use.

(c) State waters shall be free from substances attributable to sewage, industrial wastes or other wastes in concentrations or combinations, which are toxic or harmful to human, animal or aquatic life to the extent commensurate with the designated usage of such waters.

Chapter 3 Nutrient Enrichment

3.1 Eutrophication and Associated Symptoms

Eutrophication is the process of the enrichment of an aquatic ecosystem due to the excessive buildup of nutrients over time. Although eutrophication generally occurs naturally in a waterbody over a long period of time, human activities in the watershed can certainly accelerate the rate at which nutrients are being externally introduced into the aquatic ecosystem. A symptom of eutrophication in a waterbody includes the overabundant growth of algae in the water column. Through the process of the algae naturally dying and the organic material undergoing decomposition, the available dissolved oxygen in the water column is consumed and depleted. Conversely, algae also naturally replenish the water column with oxygen through the process of photosynthesis. If algae levels in a waterbody become unbalanced, this in turn can lead to extreme fluctuations in dissolved oxygen and pH levels as a result of algal photosynthesis/respiration. The severe amplitude of the maximum pH and minimum dissolved oxygen concentrations can negatively impact aquatic life.

The effects of nutrient enrichment are not just limited to the aquatic life. The excessive growth of algae can also adversely impact recreational opportunities on the waterbody. Perhaps the most obvious visual example of nutrient over-enrichment is the presence of large, unattractive mats of floating periphyton on the water surface; these noxious floating mats can adversely impact recreational activities like swimming, boating, and fishing. Furthermore, the presence of excessive algae can also lead to an increase in the incidence of harmful algal blooms. Cyanobacteria (blue-green algae) blooms can produce toxins that are considered harmful to human health through the contamination of recreational sources and most importantly drinking water sources.

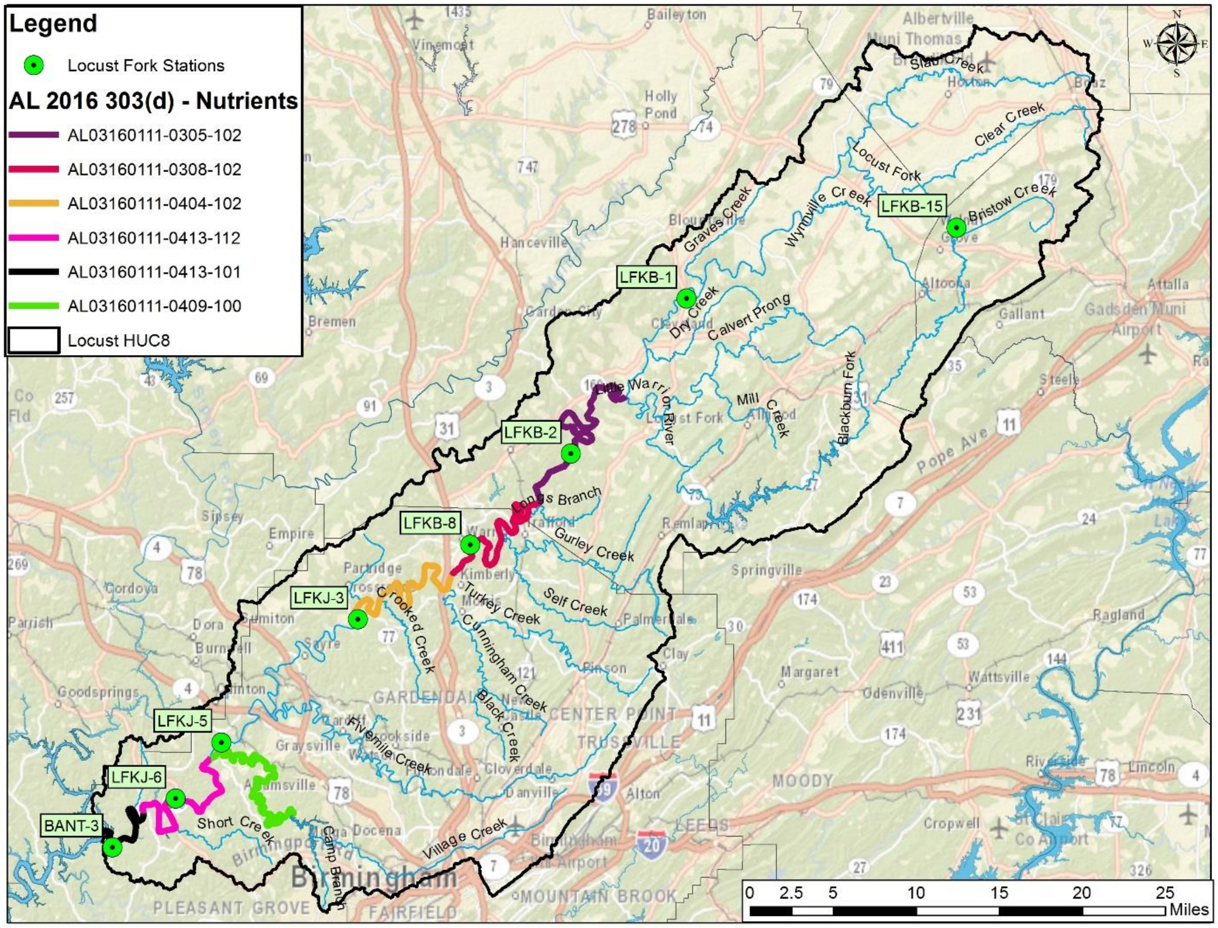
3.2 Nutrient Impairment Data Availability

The source of data that was utilized in the calibration of the water quality models and also TMDL development for the Locust Fork is from the Department's Ambient Trent Monitoring program and also the 2008 and 2012 §303(d) sampling program. During the sampling period, macro-invertebrate community assessments, habitat assessments, field parameters, and conventional lab parameters were collected at several stations along the Locust Fork. The stations were selected on the reaches of the Locust Fork that are meeting their use classification and also along the reaches impaired for nutrients that are currently listed on the Department's §303(d) List. The table below gives additional information in regards to the ADEM station locations and descriptions**.** See Figure 3.2.1 below on the following page for an illustration of the station locations in the watershed.

Table 3.2.1 Locust Fork 2012 §303(d) Monitoring Project Stations

Station ID	Trend Station	Latitude	Longitude	Location Description	Frequency
LFKB-15		34.08444	-86.28917	Locust Fork at unnamed CR approx. 1 mi NNE of Walnut Grove	Monthly (Apr – Nov)
LFKB-1	Yes	34.02370	-86.57334	Locust Fork at ALA HWY 231	Monthly (Apr – Nov)
LFKB-2		33.88849	-86.69532	Locust Fork at Armston Loop/Center Springs Rd (Vaughns Bridge)	Monthly (Apr – Nov)
LFKB-8		33.80931	-86.80075	Locust Fork at Warrior-Kimberly Road	Monthly (Apr – Nov)
LFKJ-3		33.74402	-86.91853	Locust Fork at Co Rd 77 "Hewitt Bridge"	Monthly (Apr – Nov)
LFKJ-5		33.63653	-87.06124	Locust Fork at Co Rd 45"Porter Road"	Monthly (Apr – Nov)
LFKJ-6	Yes	33.58726	-87.10933	Locust Fork at Co Rd 269 "Attwood Ferry Bridge"	Monthly (Apr – Nov)
BANT-3		33.54480	-87.17498	Locust Fork. Deepest point of the main river channel Locust Fork. Approx. 1.5 mi. upstream of Mulberry Locust confluence.	Monthly (Apr – Nov)

Figure 3.2.1 Locust Fork 2012 §303(d) Monitoring Project Stations



For the purposes of evaluating the ambient nutrient data (total phosphorus and total nitrogen), the eco-reference value has also been included with the data set. In 2010, ADEM published ecoregional reference guidelines for a number of parameters and pollutants. Reference streams, also referred to as "reference reaches" or "ecoregional reference sites," are defined as relatively homogeneous areas of similar climate, land form, soil, natural vegetation, hydrology, and other ecologically relevant variables (USEPA, 2000b) which have remained comparatively undisturbed or minimally impacted by human activity over an extended period of time in relation to other waters of the State. While not necessarily pristine or completely undisturbed by humans, reference streams do represent desirable chemical, physical and biological conditions for a given ecoregion that can be used for evaluation purposes.

The reference streams selected for a particular analysis depends primarily on the number of available reference stations and associated data within a particular ecoregion. Therefore, the total number of reference sites selected and the aerial scale (i.e. Ecoregion Level III, Level IV) used to represent a reference condition will often vary on a case-by-case basis. The eco-reference nutrient concentrations are based upon the weighted average nutrient concentration calculated from the reference sites found in the watershed for station LFKJ-3, and are intended to be representative of the wadeable segments of the Locust Fork. ADEM elected to use the 90th percentile of the data distributions from the selected eco-region reference sites for comparison to the recently collected ambient water quality data from Locust Fork. The 90th percentile of the total phosphorus (TP) and total nitrogen (TN) data distributions used in this analysis are 0.049 mg/l and 1.732 mg/l, respectively.

Figures 3.3.1.1, 3.3.1.2, and 3.3.1.3 depict the nutrient results from the Department's 2012 §303(d) sampling effort at eights stations along the Locust Fork. At each station, physical in-situ parameters in addition to water quality grab samples were collected once a month from April to November for a total of eight independent samples collected at each station.

3.3. Monitoring Results and Data Analysis

According to the *Nutrient Criteria Technical Guidance Manual for Rivers and Streams* (USEPA, 2000b), chlorophyll-a, a photosynthetic pigment and sensitive indicator of algal biomass, is considered the most important biological response variable for nutrient-related impairment problems. Elevated chlorophyll-a concentrations are indicative of a high presence of algal growth, which in turn affects the dissolved oxygen balance through photosynthesis, respiration, and the regeneration of organic materials. Therefore, in addition to comparing the ambient water quality TP and TN concentrations to the eco-reference values mentioned above, the Department will also focus on ambient algal biomass as chlorophyll-a to determine if the instream chlorophyll concentrations are indicative of nutrient over-enrichment.

In the upper reaches of the Locust Fork watershed, the stream morphology is generally characterized by a riffle run habitat type with a moderate gradient to promote free-flowing conditions year round. Furthermore, the waterbody is generally not very wide (<100 feet) and there exists a sufficient riparian buffer that helps to moderate extreme fluctuations in water temperature by controlling the availability of sunlight reaching the water surface. Considering that sunlight is a limiting factor in regards to algal production in a nutrient rich environment, both of these conditions play a very significant role in understanding the inverse relationship present between the instream nutrient concentrations vs. algal biomass levels measured as chlorophyll-a along the entire reach of the Locust Fork.

For the stations in the upper reaches of the Locust Fork watershed, the limited availability of sunlight and moderate stream velocities are inhibiting the growth of phytoplankton. Although water quality data does suggest that nutrient-enrichment conditions exist in the upper segments of the Locust Fork, the nutrient uptake in the upper reaches of the Locust Fork is restricted because sunlight is the limiting factor in regards to algae production. However, progressing further downstream the mainstem of the Locust Fork, the cross-sectional width of the water body, available sunlight reaching the water surface, and retention time are all increasing. With nutrient over-enrichment conditions already present, these factors promote an increase in algal production along the lower reaches of the Locust Fork, consequently resulting in an increase in the nutrient uptake rate through assimilation. The water quality data collected along the lower reaches of the Locust Fork illustrate this trend. Reduced concentrations of total phosphorus and total nitrogen are a result of increased algal production and nutrient uptake, illustrated by elevated chlorophyll-a concentrations.

3.3.1 Locust Fork 2012 Sampling Results - Nutrients

The box and whisker plots below summarize the water quality data collected on the Locust Fork during 2012 for conventional nutrient parameters. The "whiskers" represent the minimum and maximum observations, while the "box" represents the interquartile range (where the top line of the box is the 3rd quartile, the bottom line is the 1st quartile, and the middle line is the median of the dataset). The black diamond is representative of the average calculated concentration for that given station. The eco-reference nutrient concentrations also provided in the graphs are based upon the weighted average nutrient concentration calculated from the reference sites found in the watershed for station LFKJ-3.

Figure 3.3.1.1 Locust Fork 2012 Sampling Results – Total Phosphorus (mg/L)

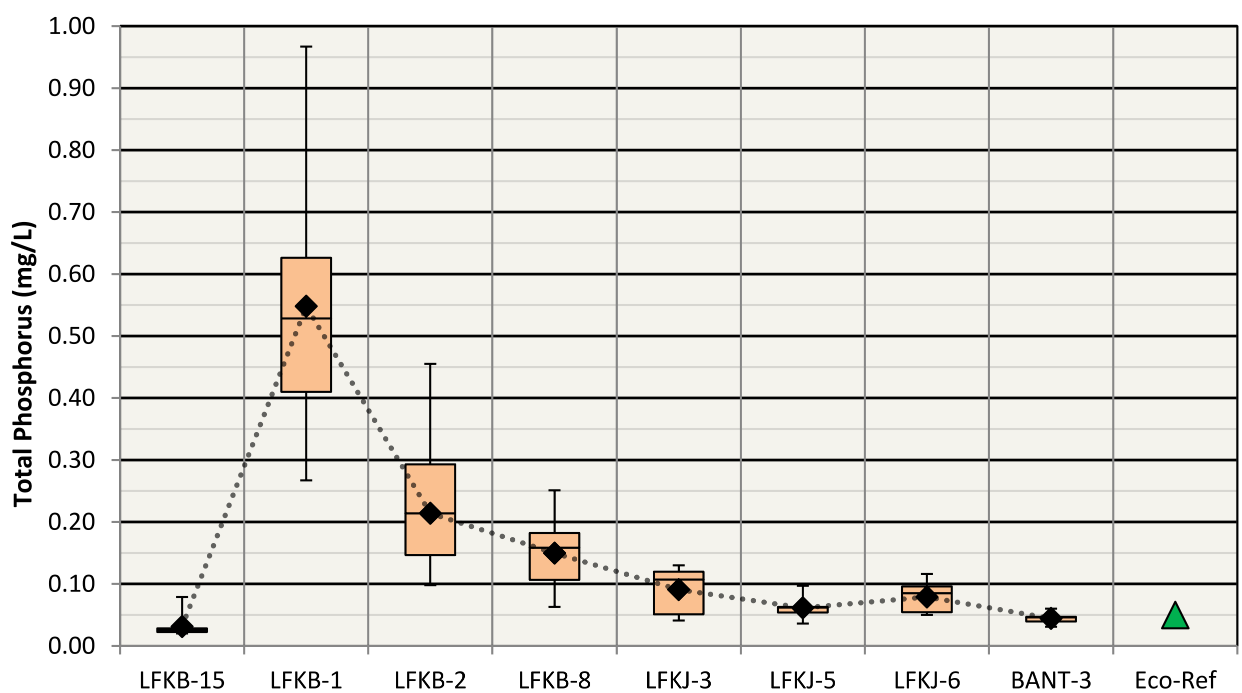


Figure 3.3.1.2 Locust Fork 2012 Sampling Results – Total Nitrogen (mg/L)

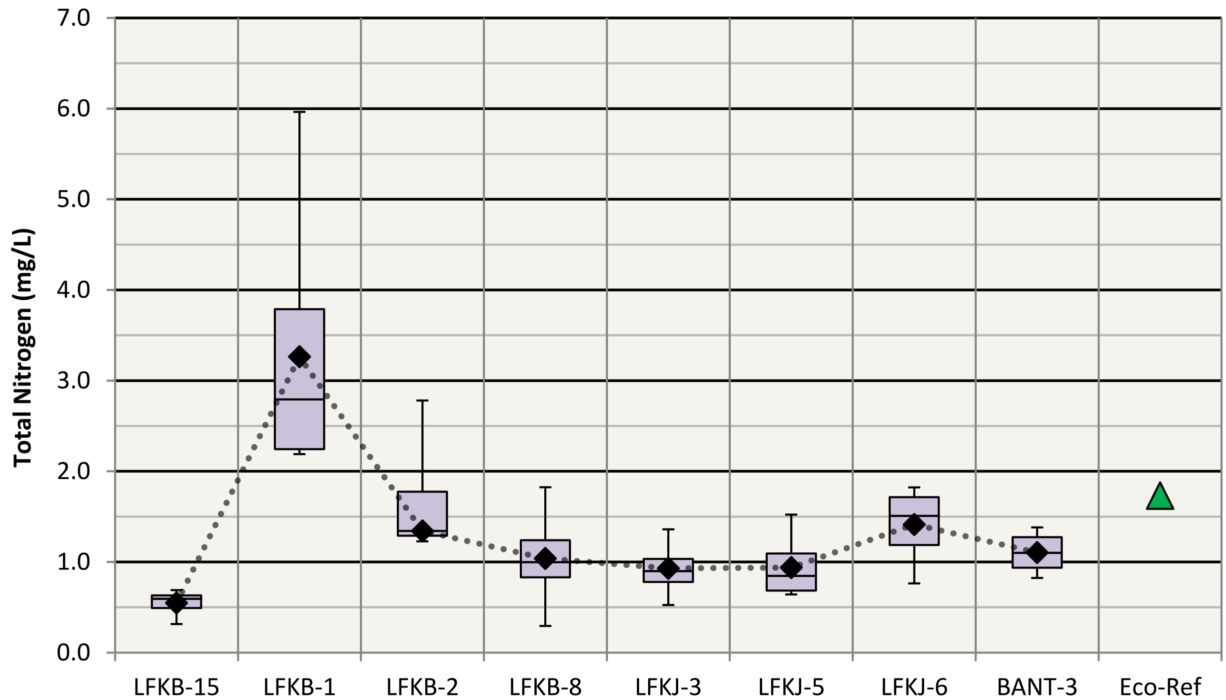
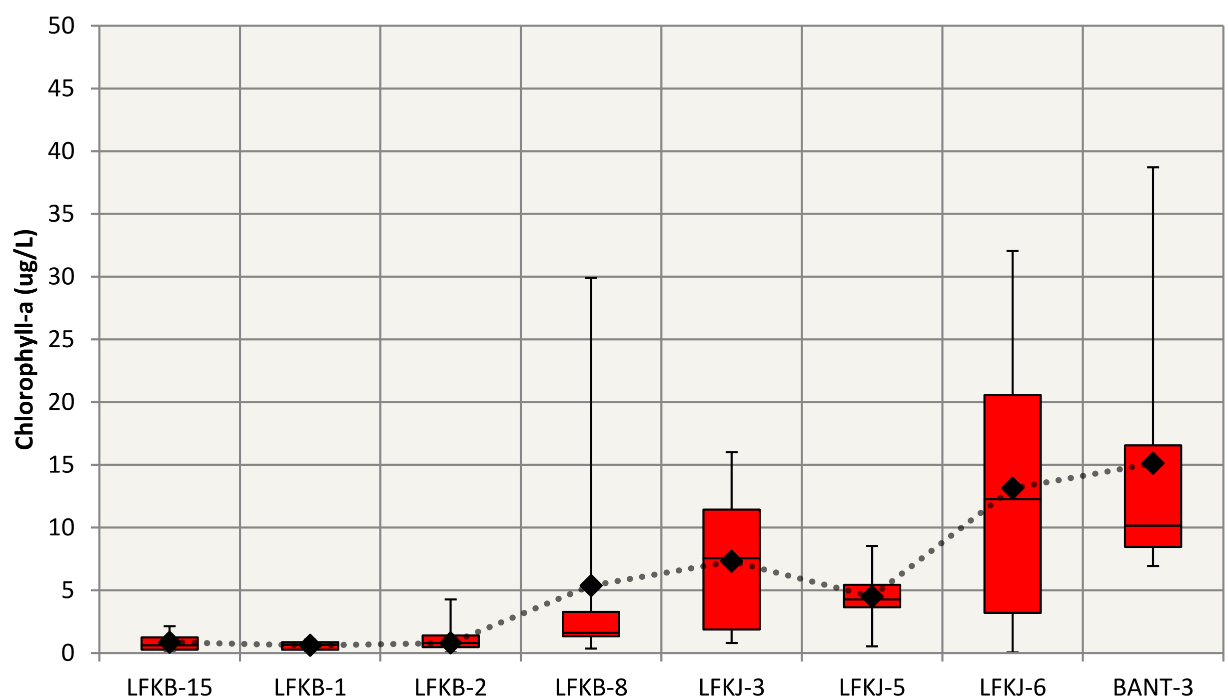


Figure 3.3.1.3 Locust Fork 2012 Sampling Results – Chlorophyll-a (µg/L)



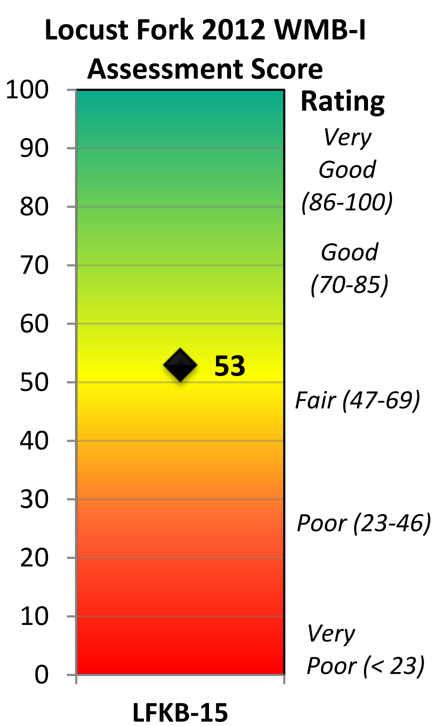
3.3.2 Locust Fork Reach – Macroinvertebrate Assessments

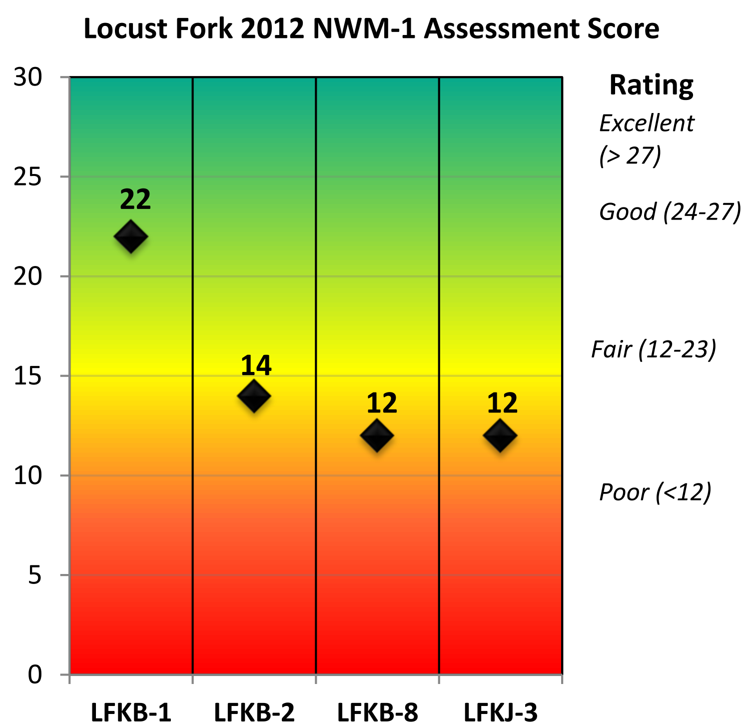
During 2012, the Department conducted an intensive assessment of the macroinvertebrate community on the Locust Fork at five stations, involving the collection of macroinvertebrates for identification and enumeration in a laboratory. Depending upon the reach characteristics at the assessment station (average depth, cross sectional width, etc.), benthic macroinvertebrate communities were sampled using either the Department's Nonwadeable Multi-habitat Bioassessment methodology (NWM-I) or the Intensive Multi-habitat Bioassessment methodology (WMB-1). Both bio-assessment methods measure the taxonomic richness, community composition, and community tolerance to assess the overall health of the macroinvertebrate community. Each score is based upon a comparison to least-impaired reference reaches characterized by similar drainage areas, gradient, and habitat.

Table 3.3.2.1 Locust Fork 2012 Macroinvertebrate Assessment Results

Station:	LFKB-15	LFKB-1	LFKB-2	LFKB-8	LFKJ-3
Date:	*5/2/2012*	*6/20/2012*	*6/20/2012*	*6/20/2012*	*6/20/2012*
Method:	WMB-1	NWM-I	NWM-I	NWM-I	NWM-I
Score:	53	22	14	12	12
Rating:					

Figure 3.3.2.1 Locust Fork 2012 Macroinvertebrate Assessment Results





The results of the macroinvertebrate assessments illustrated in the figures above indicated the overall state of the macroinvertebrate community at all five stations to be in a “fair” condition. However, the general trend based upon the assessment scores indicates the health of the macroinvertebrate communities is diminishing as you progress from the headwater station at LFKB-15 to further downstream. Based upon the assessments, the health of the macroinvertebrate communities in the downstream reaches of the Locust Fork near stations LFKB-8 and LFKJ-3 are considered to be in a borderline “fair” to “poor” condition.

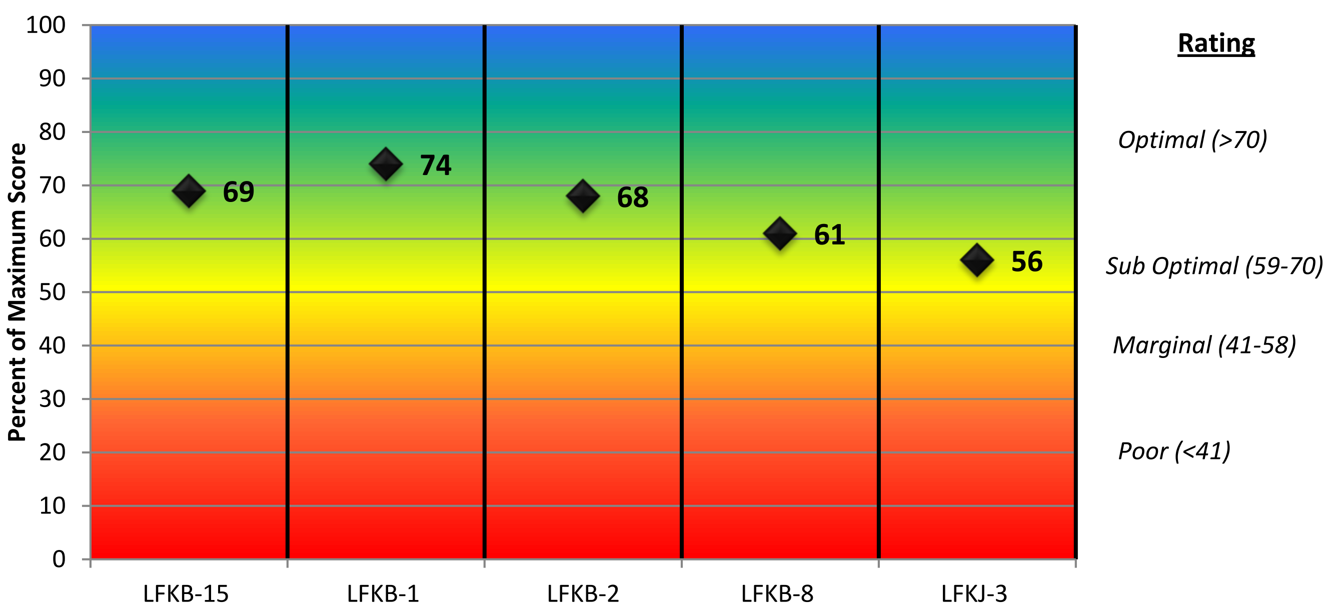
3.3.3 Locust Fork Reach – Habitat Assessments

Habitat assessments are typically conducted during the same station visit when macroinvertebrate assessments are performed. Reach characteristics and habitat conditions are evaluated based on several categories including instream habitat quality, sediment deposition, stream sinuosity, bank stability, and riparian buffer. The results are then compared to scores from reference reaches in the same or similar eco-regions in order to provide an overall indication of the quality and availability of habitat for aquatic life. Below are the results for the habitat assessments conducted for stations LFKB-15, LFKB-1, LFKB-2, LBFK-8, and LFKJ-3.

Table 3.3.3.1 Locust Fork 2012 Habitat Assessment Results

Station:	LFKB-15	LFKB-1	LFKB-2	LFKB-8	LFKJ-3
Date:	*5/2/2012*	*6/20/2012*	*6/20/2012*	*6/20/2012*	*6/20/2012*
Habitat Assessment Score:	166	177	163	146	135
% Maximum Score :	69	74	68	61	56
Rating	Sub-Optimal	Optimal	Sub-Optimal	Sub-Optimal	Marginal

Figure 3.3.3.1 Locust Fork 2012 Habitat Assessment Results



Habitat assessment scores provide an indication of the overall quality and the availability of habitat for biological communities. Therefore, macroinvertebrate assessment scores need to be evaluated in conjunction with the habitat assessment scores for each particular station. The results of the habitat assessment scores indicate the quality of habitat along the Locust Fork is sufficient to support biological communities. Progressing downstream, the overall quality of habitat gradually decreases.

3.3.4 Village Creek 2005-2011 Sampling Results – Nutrients

The box and whisker plots below summarize the water quality data collected on Village Creek during 2005-2012 for conventional nutrient parameters. The "whiskers" represent the minimum and maximum observations, while the "box" represents the interquartile range (where the top line of the box is the 3rd quartile, the bottom line is the 1st quartile, and the middle line is the median of the dataset). The black diamond is representative of the average calculated concentration for that given year. The eco-reference nutrient concentrations also provided in the graphs are based upon the weighted average nutrient concentration calculated from the reference sites found in the watershed for station VLGJ-5.

Figure 3.3.4.1 Village Creek: VLGJ-5 2005-2012 Sampling Results – Total Phosphorus (mg/L)

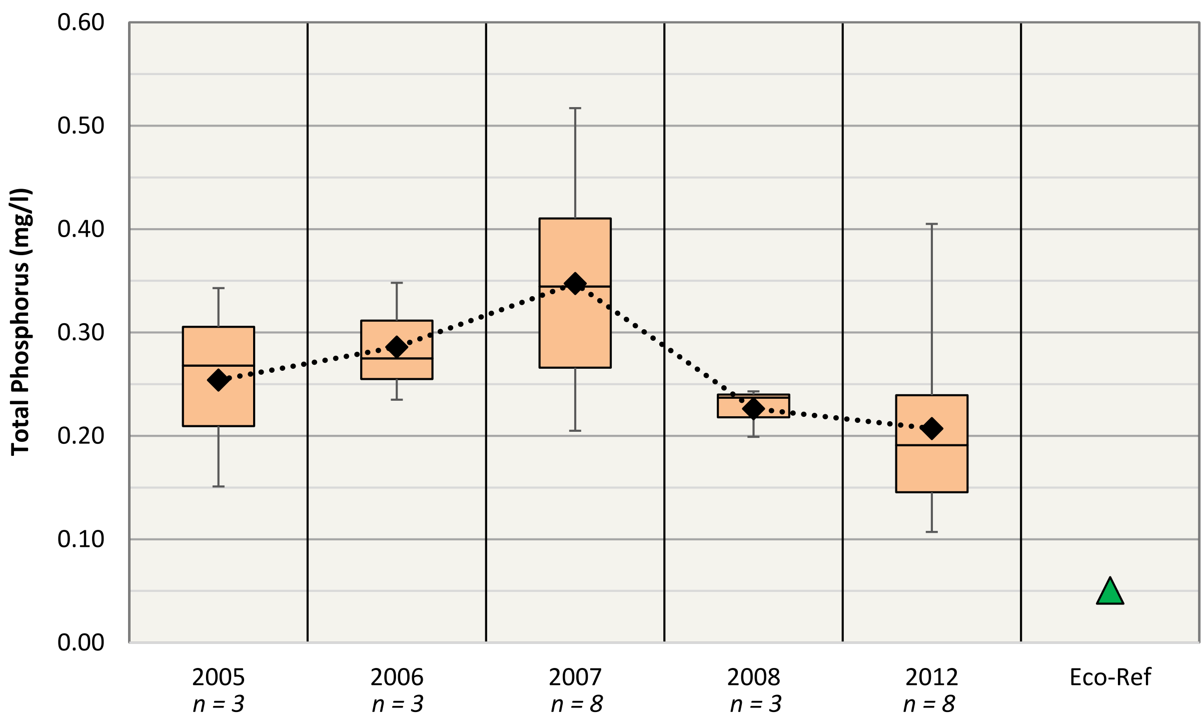


Figure 3.3.4.2 Village Creek: VLGJ-5 2005-2012 Sampling Results – Total Nitrogen (mg/L)

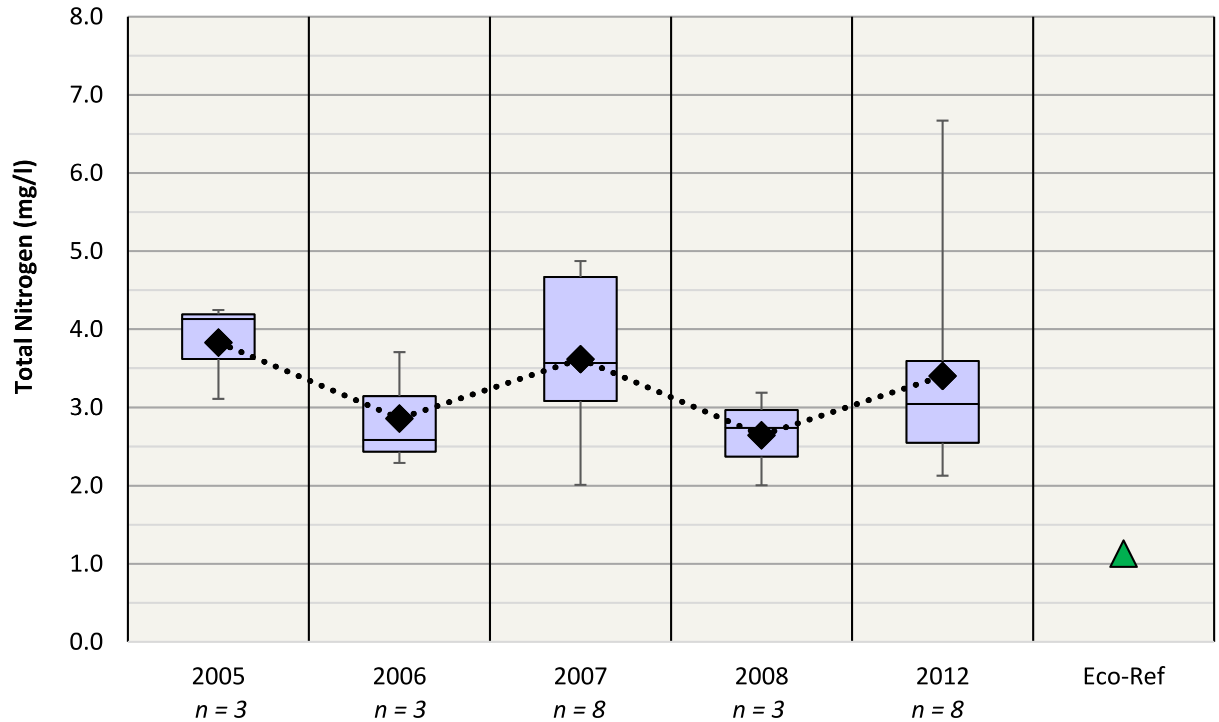
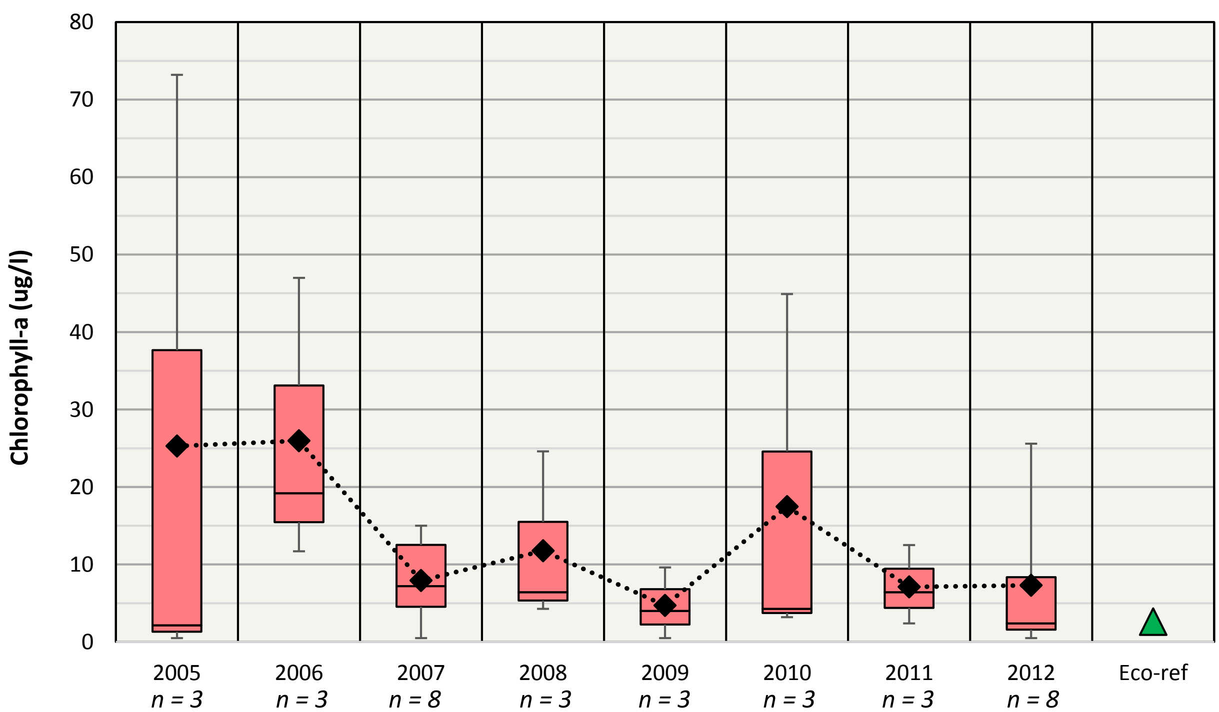


Figure 3.3.4.2 Village Creek: VLGJ-5 2005-2012 Sampling Results – Chlorophyll-a (µg/L)



The results from the Department's monitoring efforts on Village Creek at station VLGJ-5 indicate the instream nutrient concentrations are elevated, especially compared to eco-reference conditions. Furthermore, elevated instream chlorophyll-a concentrations indicate the overabundant growth of algae in the water column, a symptom of eutrophication.

Chapter 4 Source Analysis

4.1 Overview of Sources in Watershed

Pollution in a waterbody is generally understood to originate from two broad classes of sources: point sources and nonpoint sources. A critical step in the TMDL development process is identifying the two types of pollution sources in a watershed and determining how each source is contributing a pollutant load to adversely impact the waterbody.

A point source can be defined as a discernible, confined, and discrete conveyance from which pollutants are or may be discharged to waters of the state. Examples of conveyance structures associated with point sources include pipes, ditches, channel, tunnels, etc. Publicly owned treatment works (POTWs) and industrial wastewater treatment facilities are common examples of point sources located in the Locust Fork watershed. The Department regulates point sources under the National Pollutant Discharge Elimination System (NPDES) Program. For the purposes of this TMDL, point source discharges will be differentiated between two types: continuous point source discharges (e.g. POTWs) and stormwater driven point source discharges. Stormwater driven point sources include the following types of point sources which typically exhibit intermittent discharges driven by rain events but are nevertheless subject to regulation under the NPDES program: Municipal Separate Storm Sewer Systems (MS4s), Mining Outfalls, Concentrated Animal Feeding Operations (CAFOs), and Construction Stormwater Outfalls.

The Environmental Protection Agency (EPA) defines nonpoint source pollution as any source of water pollution that does not fall under the legal definition of "point source" and therefore is not regulated under the NPDES program. The primary distinction of nonpoint source pollution is that the pollution source cannot be defined as originating from any specific source or location. Rather, nonpoint source pollution originates from multiple sources over a larger area and is typically driven by rainwater runoff washing over land surfaces before depositing pollutants into the nearby receiving waterbody.

4.2 Point Source Assessment

4.2.1 Continuous Point Sources

The Alabama Department of Environmental Management has issued NPDES permits to thirty three regulated continuous point source municipal and industrial facilities that discharge within the Locust Fork watershed. A complete list of the continuous NPDES point source discharges found in the Locust Fork watershed are included in Table 4.2.1.

Continuous point source discharges in the watershed are considered to be the greatest source of pollution contributing to the nutrient impairment on the Locust Fork. A review of Department-collected water quality data reveals elevated levels of nutrients, specifically phosphorus, have been observed immediately downstream of point sources throughout the watershed. In particular, water quality data suggests the major point sources depicted in the figure below account for a sizeable portion of the nutrient loading in the watershed.

Figure 4.2.1.1 Continuous Point Sources in the Locust Fork Watershed

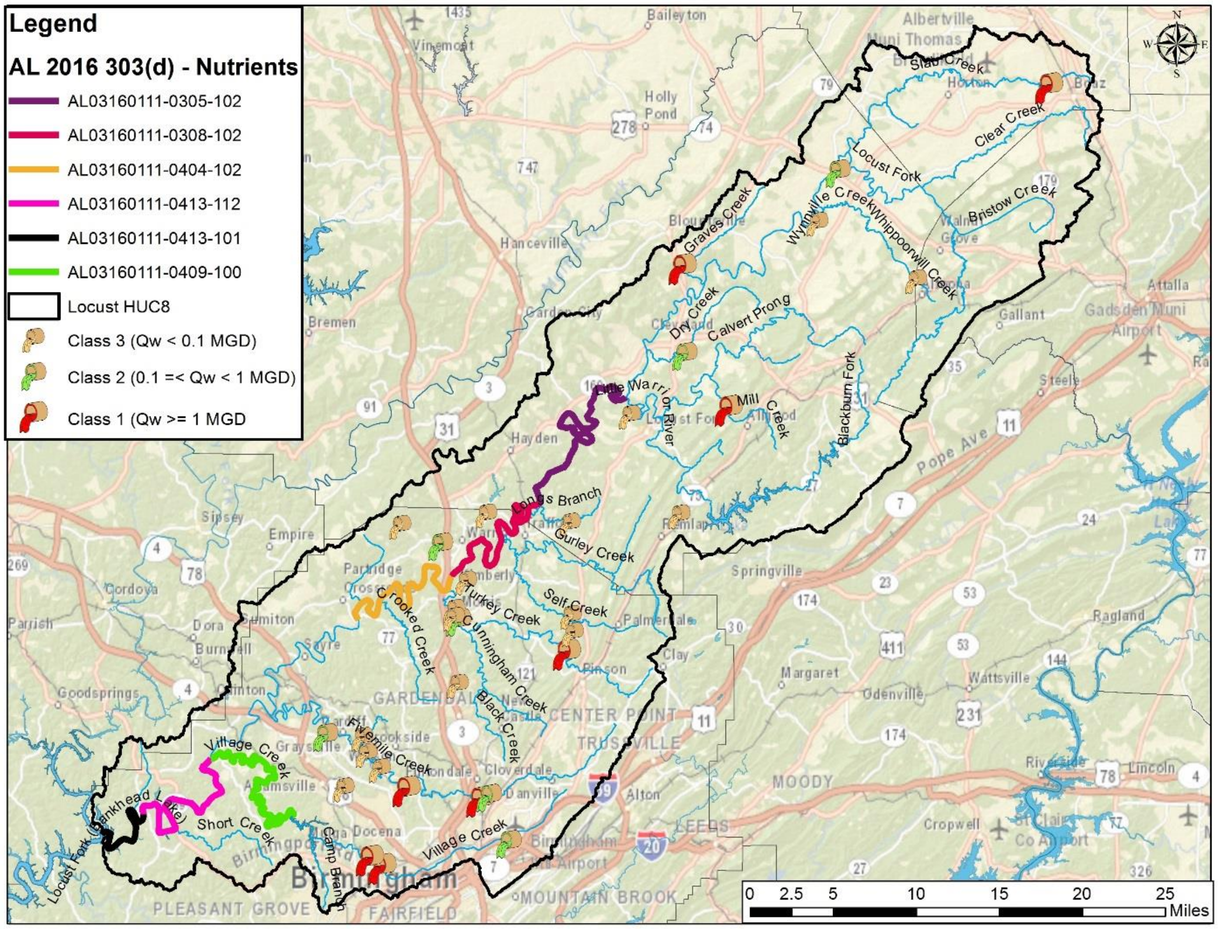


Table 4.2.1.1 NPDES Continuous Point Source Discharges in the Locust Fork Watershed

NPDES #	Latitude	Longitude	Facility	Type	Receiving Waterbody	County	Design Flow (MGD)
AL0023647	33.5267	-86.8933	Jefferson County Village Creek WWTP	Municipal	Village Creek	Jefferson	60
AL0023647	33.5339	-86.9061	Jefferson County Village Creek WWTP	Municipal	Village Creek	Jefferson	60
AL0026913	33.5942	-86.8676	Jefferson County Fivemile Creek	Municipal	Fivemile Creek	Jefferson	30
AL0049603	34.206	-86.1908	Boaz Slab Creek WWTP	Municipal	Slab Creek UT	Marshall	4.88
AL0003247	33.5853	-86.7908	ERP Compliant Coke LLC	Industrial	Fivemile Creek	Jefferson	4.73
AL0022926	33.7133	-86.6997	Jefferson County Turkey Creek WWTP	Municipal	Turkey Creek	Jefferson	5
AL0049549	33.9261	-86.5292	Oneonta WWTP	Municipal	Mill Creek	Blount	2.2
AL0001449	34.0499	-86.577	Tyson Foods Blountsville	Industrial	Graves Creek	Blount	1.339
AL0056120	33.6416	-86.9522	Jefferson County Prudes Creek WWTP	Municipal	Fivemile Creek	Jefferson	0.9
AL0053121	33.7419	-86.8131	Morris Manor Apartments WWTP	Municipal	Turkey Creek	Jefferson	0.5
AL0001554	33.5482	-86.7608	CMC Steel Alabama	Industrial	Village Creek UT	Jefferson	0.380
AL0003417	33.5886	-86.7814	ABC Coke, Drummond Company Inc.	Industrial	Fivemile Creek	Jefferson	0.404
AL0058572	34.1328	-86.413	Snead WWTP	Municipal	Locust Fork	Blount	0.15
AL0073261	33.9741	-86.5752	Cleveland WWTP	Municipal	Dry Creek UT	Blount	0.15
AL0050881	33.8081	-86.8319	Jefferson County Warrior WWTP	Municipal	Cane Creek	Jefferson	0.10
AL0071170	33.8269	-86.6961	County Line Industrial Park WWTP	Municipal	Longs Branch	Blount	0.099
AL0051055	33.6861	-86.8139	Peachtree Crossing Mobile Home Park	Municipal	Black Creek UT	Jefferson	0.09
AL0076261	33.8349	-86.7838	West Blount Lagoon	Municipal	Hogeland Creek	Jefferson	0.09
AL0021237	34.0379	-86.3318	Altoona Lagoon	Municipal	Locust Fork	Etowah	0.07
AL0027642	33.6125	-86.8956	Forestdale MHP	Municipal	Fivemile Creek	Jefferson	0.03
AL0050563	34.0887	-86.435	Susan Moore High School	Municipal	Locust Fork UT	Blount	0.03
AL0056553	33.7518	-86.8174	The Cove Mobile Home Park	Municipal	Turkey Creek	Jefferson	0.024
AL0054348	33.9208	-86.6328	Locust Fork High School Lagoon	Municipal	Blackburn Fork	Blount	0.022
AL0062251	33.64	-86.9136	Brookside Village WWTP	Municipal	Newfound Creek	Jefferson	0.022
AL0032301	33.7312	-86.6936	Dixie-Manor Housing Project	Municipal	Self Creek UT	Jefferson	0.020
AL0071170	33.8269	-86.6961	County Line Industrial Park WWTP	Municipal	Longs Branch	Blount	0.020
AL0051161	33.5958	-86.9333	Bottenfield Junior High School	Municipal	Prudes Creek UT	Jefferson	0.017
AL0047546	33.8253	-86.8736	Bradford Parkside Health Services	Municipal	Thomas Creek	Jefferson	0.015
AL0054011	33.7448	-86.8175	River Bend Townhouses WWTP	Municipal	Turkey Creek	Jefferson	0.015
AL0075256	33.7764	-86.805	North Jefferson Middle School WWTP	Municipal	Lick Creek	Jefferson	0.012
AL0051195	33.7461	-86.6955	Johnson Elementary School Lagoon	Municipal	Self Creek UT	Jefferson	0.01
AL0068675	33.8339	-86.5811	Southeastern Elementary School	Municipal	Campbell Creek	Blount	0.005
AL0057827	33.6256	-86.91	Sharon Heights MHP	Municipal	Fivemile Creek	Jefferson	0.003

During low flow conditions, the major NPDES permitted dischargers to Village Creek, Fivemile Creek, and Slab Creek dominate the receiving waterbody by accounting for a significant percentage of the overall stream flow. For example, see the figure below depicting the measured daily mean stream flow at two USGS gages on Village Creek during the drought year of 2007. The USGS gages are separated by only 3.8 stream miles and a drainage area of 18.7 square miles. During 2007, the average measured streamflow difference between the USGS stream gages was approximately 36 cfs. The wide discrepancy between measured stream flows is attributable to the Jefferson County Village Creek WWTP (NPDES # AL0023647), which has two major outfalls located on Village Creek in between the USGS gages. Table 4.2.1.2 below illustrates that, during the drought year of 2007, the measured streamflow at USGS gage 02458600 downstream of the Jefferson County Village Creek WWTP was very heavily dominated by effluent, with the average percentage of effluent in the total stream flow ranging from 55% to 93% during the growing season months.

Figure 4.2.1.2 USGS Measured Daily Stream Flow on Village Creek during 2007

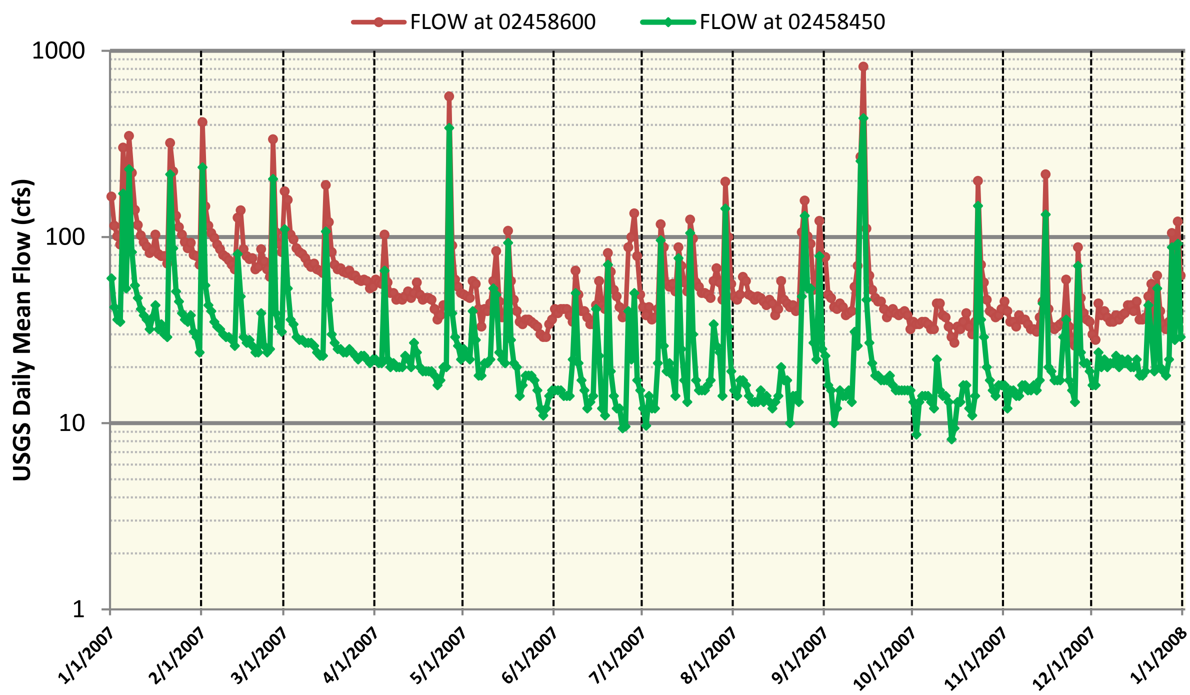


Table 4.2.1.2 2007 Village Creek Average Monthly Streamflow

	2007 Average Monthly Flow (cfs)							
	April	May	June	July	August	September	October	November
USGS 02458600 (downstream of AL0023647)	69.40	44.23	52.50	65.68	59.19	80.73	42.87	44.17
AL0023647 Outfalls 011[a] + 021[a]	43.63	40.54	37.76	41.00	38.31	44.72	39.32	38.06
Effluent % in streamflow	63%	92%	72%	62%	65%	55%	93%	86%

a. Monthly Average Effluent flowrate obtained from DMRs

4.2.2 Municipal Separate Storm Sewer Systems (MS4)

Urban areas designated as part of the Municipal Separate Storm Sewer System (MS4) program are regulated by NPDES, and as such, are considered to be point sources by EPA and receive Waste Load Allocations (WLAs) under these TMDLs. The EPA defines an MS4 as *" a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):*

(i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law);
(ii) Designed or used for collecting or conveying stormwater;
(iii) Which is not a combined sewer; and
(iv) Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2."

During rain events in an urbanized watershed, stormwater runoff has the potential to collect harmful pollutants which are transported through MS4 systems before discharging into state waters. Therefore, in 1990 the EPA developed the NPDES stormwater program which promulgated rules, in two different phases, in order to address the potential negative water quality effects associated with stormwater runoff. In 1990, the EPA issued Phase I regulations under the NPDES stormwater program which required both medium and large cities and also counties with populations of 100,000 or more to obtain NPDES permit coverage specifically for their stormwater discharges. In 1999, the second phase of the NPDES stormwater program amended existing regulations in addition to requiring NPDES permits for stormwater discharges from certain small MS4 systems.

The MS4 NPDES regulated permittees that are addressed in the TMDL process include those Phase I and Phase II permittee municipalities covered under the MS4 NPDES program whose boundaries of urban areas as designated by ADEM are located within the Locust Fork watershed. The tables and figure below identify those specific permittees.

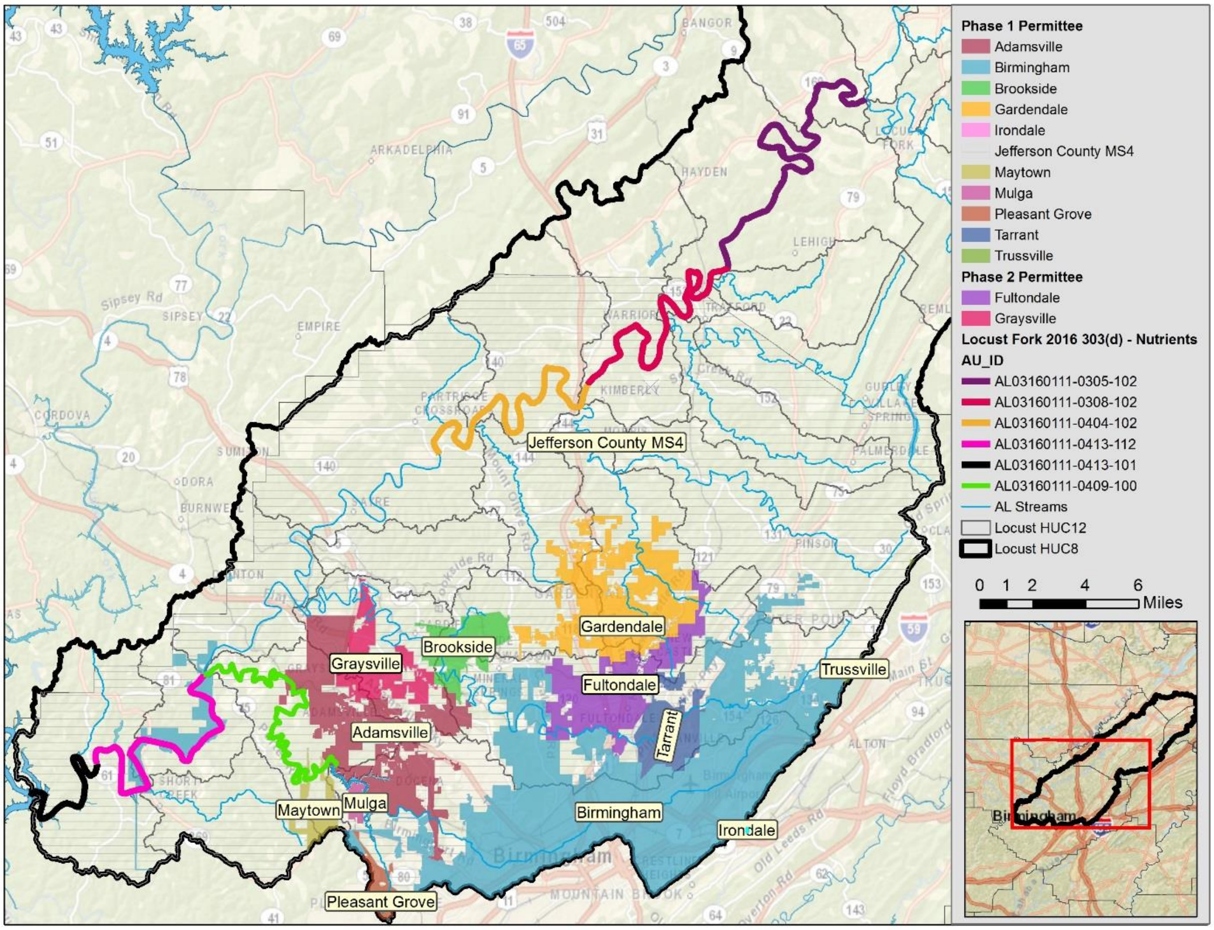
Table 4.2.2.1 NPDES Phase I MS4 Municipalities in the Locust Fork Watershed

Permittee Name	NPDES Permit
Adamsville	ALS000001
Birmingham	ALS000001
Brookside	ALS000001
Gardendale	ALS000001
Irondale	ALS000001
Jefferson County	ALS000001
Maytown	ALS000001
Mulga	ALS000001
Pleasant Grove	ALS000001
Tarrant	ALS000001
Trussville	ALS000015

Table 4.2.2.2 NPDES Phase II MS4 Municipalities in the Locust Fork Watershed

Permittee Name	NPDES Permit
Graysville	ALR040038
Fultondale	ALR040037

Figure 4.2.2.1 Locust Fork Watershed - Phase II and II MS4 Boundary Areas



4.2.3 NPDES Permitted Mining Facilities

Mineral production, specifically coal mining, has historically been a significant industry in the Black Warrior watershed. The Department conducted a comprehensive water quality study (Assessment of Water Quality in Wadeable Streams near Surface Coal Mining Facilities in the Black Warrior River Basin in Alabama) from January 2011 to February 2013 in order to evaluate the effects of discharges from coal mining facilities on water quality and also aquatic macroinvertebrate communities in the wadeable streams of the Black Warrior basin. In regards to measured nutrient concentrations, the results of the study indicated the mean concentration of total phosphorus in streams downstream of coal mining facilities was not significantly different ($p>0.05$) from the mean concentrations of total phosphorus measured at eco-regional reference stations (ADEM 2013).

Furthermore, the Department has also required NPDES permitted coal mining facilities that discharge to the nutrient impaired segments of the Locust Fork to routinely monitor for nutrient related parameters in order to gain a better understanding of their potential pollutant load contribution to the waterbody. An analysis of the submitted monthly Discharge Monitoring

Reports (DMRs) from those facilities reveals effluent total phosphorus loading to the receiving waterbody is usually quite minimal; typically measured concentrations of total phosphorus are below the method detection limit.

The Department has concluded that both active and inactive coal mining facilities in the Locust Fork watershed are not contributing to the existing nutrient impairment based upon an assessment of the results from the coal mining study and also a review of the monitoring results from coal mining facilities in the Locust Fork watershed. Therefore, a WLA will not be established at this time for NPDES permitted mining facilities in the Locust Fork watershed.

4.2.4 Concentrated Animal Feeding Operations (CAFOs)

Currently, there are several NPDES permitted CAFO facilities in the upper extent of the Locust Fork watershed. However, Departmental regulations for AFOs/CAFOs prohibit the discharge of pollutants from both the facility itself and also associated land application activities to nearby waters of the state. Under Departmental rules, all CAFOs are mandated to register with ADEM, and all AFO/CAFOs are required to implement and maintain effective best management practices (BMPs) for animal waste production, storage, treatment, transport, and proper disposal or land application that meet or exceed USDA - Natural Resources Conservation Service (NRCS) technical standards and guidelines.

4.2.4 NPDES Construction Stormwater General Permits

Discharges from construction activities that result in a total land disturbance of one acre or greater (including sites less than one acre but that are part of a common plan of development or sale) are regulated through ADEM's Stormwater Management Branch. Permitted discharges are required to adhere to erosion and sediment controls which reduce stormwater velocity and volume, minimize amount of soil exposed, minimize stream crossings, provide and maintain buffers around surface waters, etc. Furthermore, operators & owners of all regulated construction sites must implement and maintain effective erosion and sediment controls in accordance a Construction Best Management Practices Plan (CBMPP) prepared and certified by a Qualified Credentialed Professional (QCP).

The Department believes that total phosphorus loads originating from construction stormwater sources are not a contributing factor to the existing nutrient impairment on the Locust Fork and Village Creek. Therefore, a WLA will not be established at this time for NPDES permitted construction stormwater facilities located in the Locust Fork watershed.

4.3 Nonpoint Source Assessment

Due to the size of the contributing drainage area of the Locust Fork, there are a wide variety of land use types found in the watershed. Figure 4.3.1 and Table 4.3.1 depict the 2011 National Land Cover Database (NLDC 2011) land cover results for the Locust Fork Watershed. The NLCD 2011 is based primarily on a decision-tree classification of circa 2011 Landsat satellite data.

The predominant land use types in the Locust Fork watershed are primarily dependent upon the relative location in the watershed. In the mid to upper regions of the Locust Fork watershed, the predominant land use types are forested and agriculture. Compared to other land uses, potential sources of nutrient enrichment from forested land cover are generally considered to be minimal. Furthermore, forested land tends to serve as a natural filter of pollution originating from other sources within its drainage area.

Agricultural practices in a watershed can account for a significant source of nonpoint source pollution to nearby rivers and streams. Nonpoint source pollution typically associated with agriculture land cover includes the following:

- stormwater runoff from pastures and exposed soil
- mismanaged animal feeding operations
- improper land application of fertilizer including animal wastes
- farm animals with direct access to waterbodies

In the south-eastern extent of the Locust Fork watershed found within Jefferson County, the predominant land use type is developed (i.e., urbanized areas). Urban development in a watershed can lead to a number of changes to the hydrological regime including dramatic increases to the peak discharge and also an increase in the frequency of floods. Furthermore, stormwater runoff over impervious surfaces found in urban areas, like for example sidewalks and asphalt parking lots, can collect a variety of pollutants which eventually end up deposited into nearby waterbodies. Additional sources of nonpoint source pollution from developed land use cover include, but are not limited to:

- excessive nutrients and pesticides from lawns and greenspaces
- runoff from improper disposal of waste materials
- on-site septic systems failures
- thermal pollution associated with impervious surfaces in the watershed.

Figure 4.3.1 Locust Fork Watershed 2011 NLCD

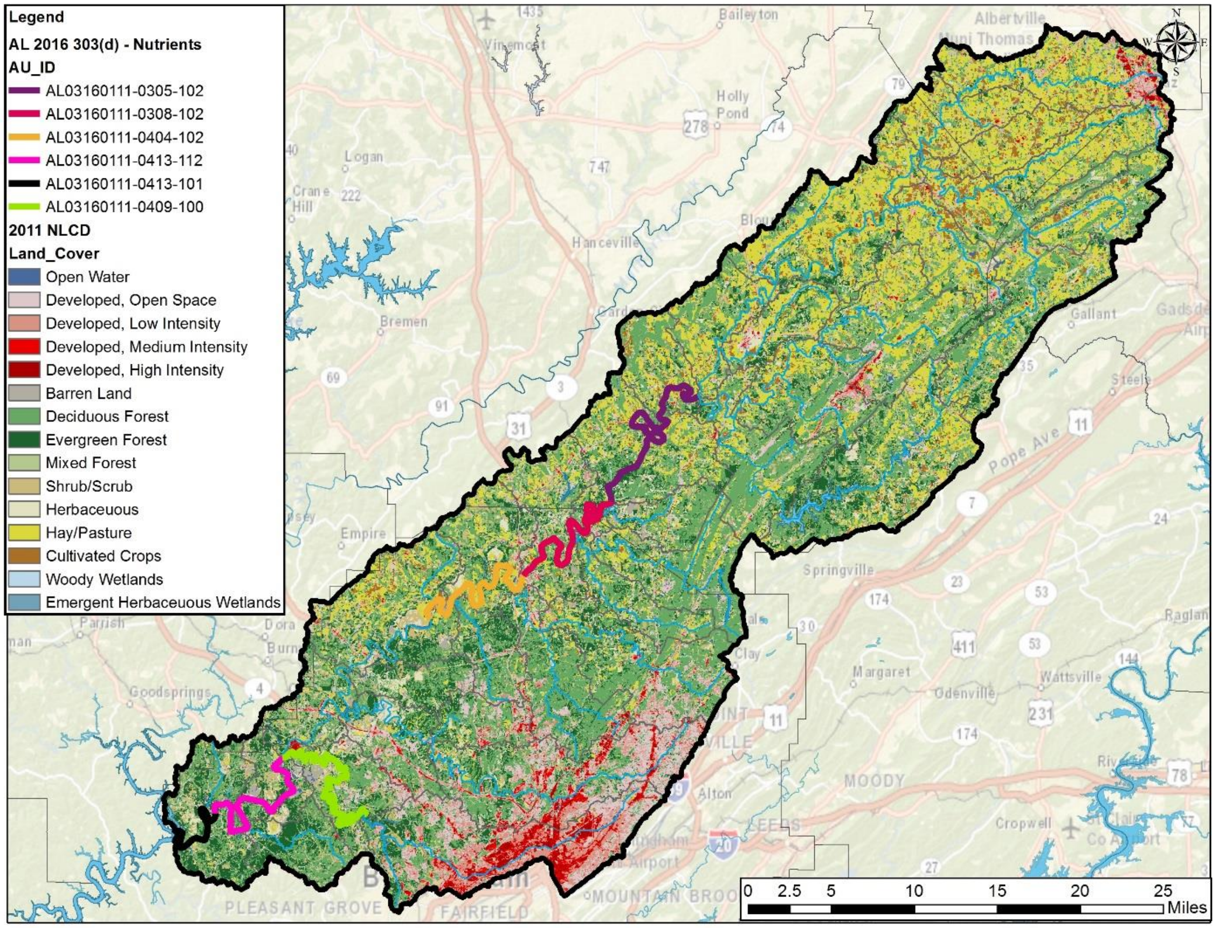


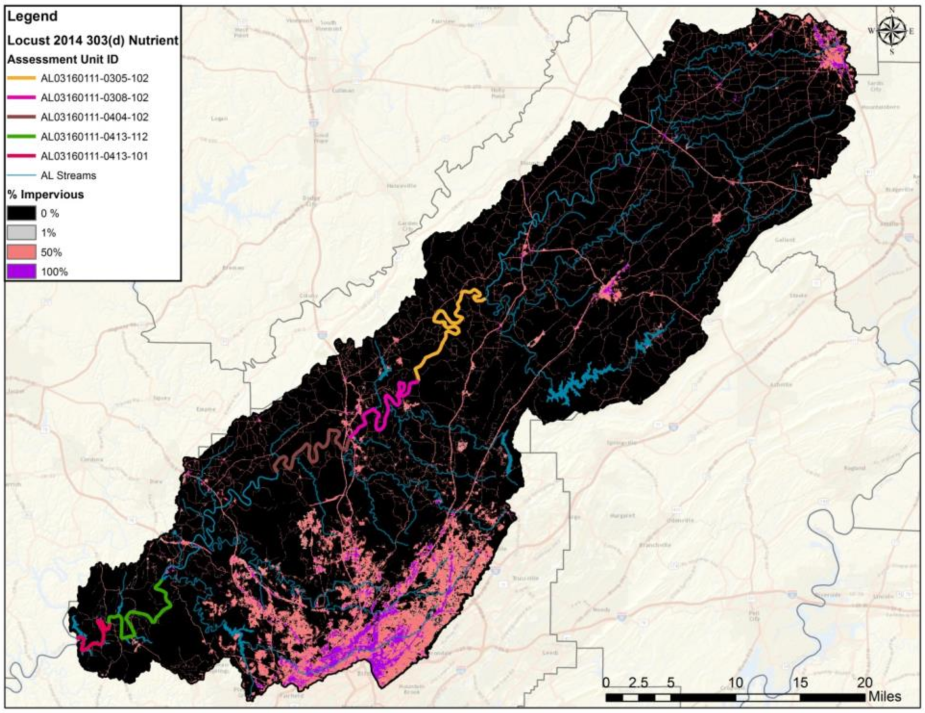
Table 4.3.1 Locust Fork Watershed 2011 NLCD

Land Use Description	Acres	Square Miles	Percent (%)
Open Water	7832	12.2	1.0%
Developed, Open Space	64494	100.8	8.3%
Developed, Low Intensity	33759	52.7	4.4%
Developed, Medium Intensity	12987	20.3	1.7%
Developed, High Intensity	5322	8.3	0.7%
Barren Land	6815	10.6	0.9%
Deciduous Forest	239187	373.7	30.9%
Evergreen Forest	98390	153.7	12.7%
Mixed Forest	47985	75.0	6.2%
Shrub/Scrub	45961	71.8	5.9%
Herbaceuous	35505	55.5	4.6%
Hay/Pasture	146097	228.3	18.9%
Cultivated Crops	24361	38.1	3.1%
Woody Wetlands	5322	8.3	0.7%
Herbaceous Wetlands	288	0.4	0.0%
Sum	***774305***	***1210***	***100%***

Cumulative Land Use	Acres	Square Miles	Percent (%)
Developed	116562	182	15.1%
Forested	391172	611	50.5%
Agriculture	170458	266	22.0%
Grassland/Shrubs	81466	127	10.5%
Barren Land	6815	11	0.9%
Open Water	7832	12	1.0%
Sum	***774305***	***1210***	***100%***

The figure below illustrates the percent impervious surfaces in the Locust Fork Watershed. The gradient ranges from a fully pervious surface, represented in the figure below by the black color, to a completely impervious surface, represented in the figure below by the dark purple. As expected, the impervious surfaces are found in the urbanized and developed areas of the watershed.

Figure 4.3.2 Locust Fork Water Impervious Cover Percentage (%)



In an effort to determine the degree to which nonpoint source pollution is contributing to the nutrient impairment on the Locust Fork, the Department has monitored water quality conditions upstream of continuous point source discharges on the Locust Fork in the upper reaches of the watershed that are characterized by rural and agriculture land use types. The resulting average instream total phosphorus concentrations are typically at or near eco-reference conditions (e.g., station LFKB-15 on Figure 3.3.1.1), indicating that, in general, the nutrient loading to the waterbody from these nonpoint sources in the watershed is minimal.

Chapter 5 Technical Approach for TMDL Development

5.1 Modeling Effort Overview

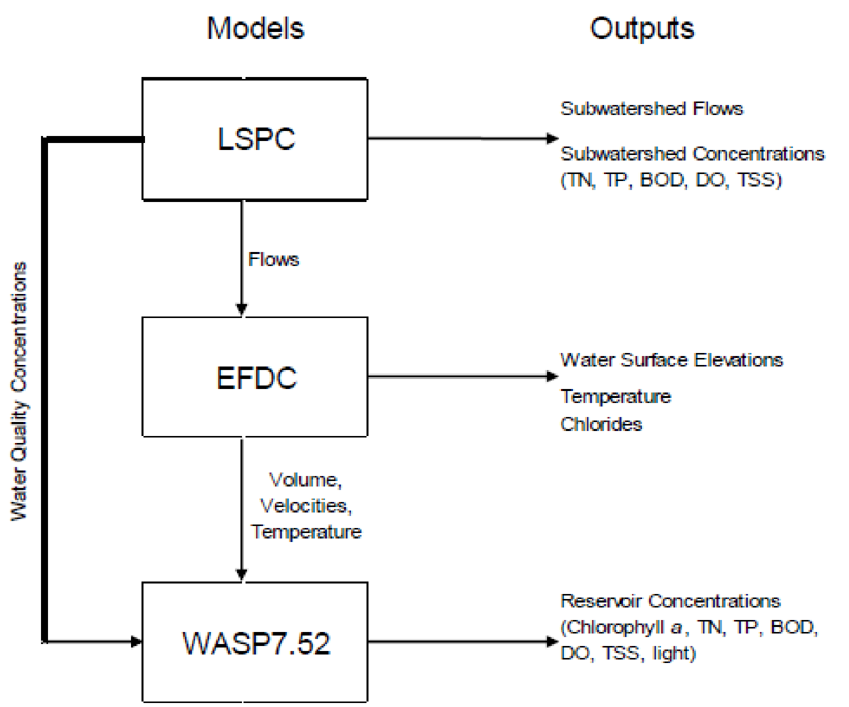
The technical TMDL development process for the Locust Fork utilized a series of dynamic water quality models in order to accurately predict the necessary nutrient reductions in the watershed in order to meet the established numeric chlorophyll-a target in the Locust Fork embayment. The application of each model to develop the Locust Fork TMDL was used as follows:

- The Loading Simulation Program in C++ (LSPC) model was utilized to simulate both the hydrological and water quality conditions in the Locust Fork watershed. LSPC is a dynamic model driven by time-variable weather and point source discharge data. The flow and temperature output from the LSPC model was used as input for the EFDC model in the reservoir embayment segment of the Locust Fork. The water quality output from the LSPC model was used as input for the WASP model in the reservoir embayment segment of the Locust Fork.

- The Environmental Fluid Dynamics Code (EFDC) program was used to simulate the hydrodynamic conditions (stage height, flow, temperature) of the Bankhead Reservoir and the non-wadeable segments of the Locust Fork.

- The Water Quality Analysis Simulation Program (WASP) was used to simulate the water quality conditions of the Bankhead reservoir and the non-wadeable segments of the Locust Fork.

Figure 5.1.1 Linkage between Dynamic Models



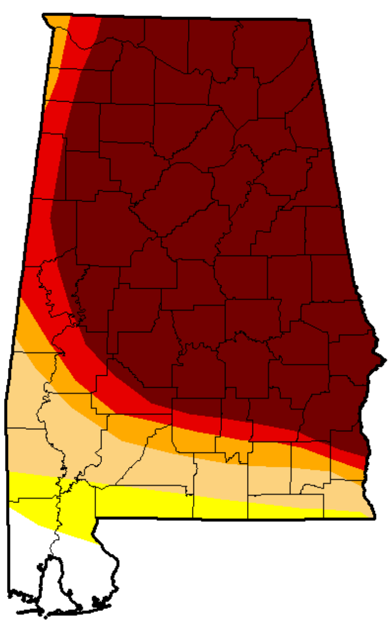
The three individual modeling programs (LSPC, EFDC, and WASP) were executed to dynamically simulate the period from January 1, 2007 to December 31, 2012. The year of 2006 was included in addition to the simulation period in order to allow for a sufficient "spin-up" time to assure that the model output was not being influenced by the initial conditions in the model. The simulation period of January 1, 2007 to December 31, 2012 was chosen for the following reasons:

- The Department's Rivers and Streams Monitoring Program (RSMP) basin rotation approach involved intensively sampling each major river basin every five years. The RSMP sampled the wadeable streams in the Black Warrior River basin watershed during 2007 and 2012. Therefore, the data utilized to calibrate the LSPC watershed model included yearly data sets from at least two independent years.
- In 2007 and 2012, the Department monitored the Bankhead Reservoir as part of the Rivers and Reservoirs Monitoring Program (RRMP). Therefore, the data utilized to calibrate the WASP reservoir water quality model included yearly data sets from at least two independent years.
- During the summer months of 2007, the US Drought Monitor declared the majority of the Black Warrior watershed to be under exceptional drought conditions. Drought conditions are characterized by extremely low natural stream flows which negatively impact water quality by reducing ambient stream flow velocity, increasing ambient water temperature, and reducing the amount of water available to dilute and assimilate pollutants from point source discharges in the watershed.

Figure 5.1.2 US Drought Monitor for Alabama – October 30, 2007

U.S. Drought Monitor

Alabama



October 23, 2007

(Released Thursday, Oct. 25, 2007)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	3.88	96.12	90.33	79.19	73.04	63.68
Last Week 10/16/2007	0.00	100.00	99.97	93.23	83.12	73.04
3 Months Ago 7/24/2007	0.00	100.00	90.28	71.55	41.56	17.74
Start of Calendar Year 1/2/2007	51.87	48.13	0.00	0.00	0.00	0.00
Start of Water Year 9/25/2007	1.40	98.60	90.18	81.92	71.11	48.72
One Year Ago 10/24/2006	15.38	84.62	34.20	0.00	0.00	0.00

Intensity:

D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

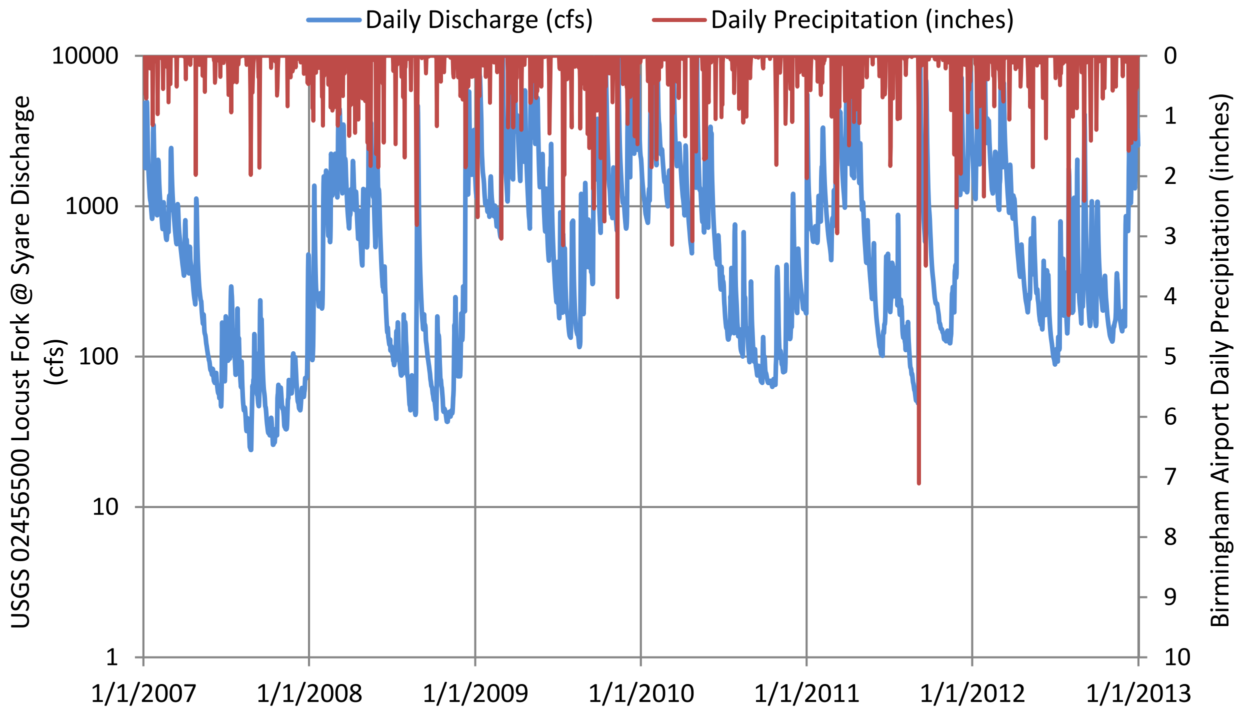
Author:
Mark Svoboda
National Drought Mitigation Center

http://droughtmonitor.unl.edu/

- The graph below illustrates the daily streamflow recorded at USGS 02456500 Locust Fork at Sayre and also the measured daily precipitation from the Birmingham Airport. The graph demonstrates the effect of the 2007 drought on the measured stream flows in the

Locust Fork. During the modeled period of record, the minimum recorded Locust Fork flows occurred on August 25, 2007 (24 cfs).

Figure 5.1.3 Daily Discharge: USGS 02456500 Locust Fork at Sayre



5.2 LSPC Watershed Model

The LSPC watershed model was used to simulate both the hydrodynamic conditions and the water quality loadings for all the waterbodies in the Locust Fork watershed. The LSPC watershed model was set up to simulate a series of hydraulically linked sub-watersheds. In each sub-watershed, the model simulates the assimilation of conservative and non-conservative constituents in the water column in addition to the overland surface water runoff loadings from the watershed. A total of ninety-nine individual sub-watersheds were simulated in the Locust Fork watershed. The LSPC output (including both hydrodynamic and water quality) from the sub-watershed adjacent to the Locust Fork mainstem in the Bankhead reservoir became the input boundary conditions for the EFDC hydrodynamic model and the WASP water quality model.

5.2.1 Point Source Assessment and Inputs

A total of 33 individual NPDES permitted point source dischargers located in the Locust Fork watershed were included in the LSPC watershed model. Discharge monitoring reports (DMRs) submitted to the Department for the modeled period of January 1, 2006 to December 31, 2012 were assessed in order to obtain the monthly effluent pollutant concentrations and discharge flowrates for the LSPC model input. When monthly effluent data was not available for a given parameter, an average of the available data set was used to represent most probable discharge concentrations for months during the study period. Furthermore, if a facility was not required to monitor for a given parameter and there was no data available, the following assumptions were made based on the available dataset:

- Organic Nitrogen (ON) = 0.5 x Total Kjeldahl Nitrogen (TKN)
- Organic Phosphorus (OP) = 0.2 x Total Phosphorus (TP)
- Orthophosphate (PO4) = 0.8 x Total Phosphorus (TP)

The following pollutant parameters were included in the LSPC watershed model on a monthly time step for each point source during 2006 through 2012:

- Effluent Flowrate (MGD)
- Total Kjeldahl Nitrogen (TKN)
- Nitrate – Nitrite (NOx)
- Orthophosphate (PO4)
- Total Phosphorus
- Ammonia Nitrogen (NH3-N)
- Organic Nitrogen (ON)
- Total Nitrogen (TN)
- Organic Phosphorus (OP)
- Dissolved Oxygen (DO)
- 5-day Carbonaceous Biochemical Oxygen Demand (CBOD5)

5.2.2 Locust Fork Watershed Surface Water Withdrawal Sources

Surface water withdrawal sources in the Locust Fork watershed were also included in the LSPC model. The input data for the LSPC model was characterized by the average daily water withdrawal flowrates reported to the Department during the simulation period of January 1, 2006 to December 31, 2012. The table below provides information regarding the two surface water withdrawal sources in the Locust Fork watershed:

Table 5.2.2.1 Locust Fork Watershed Surface Water Withdrawal Sources

Permit	System Name	Source Water	Average Daily Withdrawal (MGD)	Plant Capacity Withdrawal (MGD)
AL0000738	Birmingham Water Works and Sewer Board	Inland Lake	41.75[a]	90
AL0000103	Oneonta Utilities Board	Calvert Prong	1.58[a]	3

a. Average Daily Withdrawal rates from 1/1/2006 to 12/31/2012
Note: Table above includes only the surface water withdrawal sources in the LSPC model. The withdrawal sources on the Bankhead Reservoir are included in the EFDC model.

5.2.3 Meteorological Data

Both watershed hydrology and water quality are significantly influenced by weather conditions. Therefore, accurate and comprehensive weather data is a critical component of the LSPC watershed model. The following Summary of Day (SOD) and Surface Airways (SA) meteorological data collected by the National Climate Data Center (NCDC) were included in the LSPC watershed model:

- Precipitation
- Dew Point Temperature
- Cloud Cover
- Solar Radiation
- Air Temperature
- Wind Speed
- Evaporation

The table below depicts the NCDC SOD and SA station pairings used in the Locust Fork LSPC watershed model.

Table 5.2.3.1 LSPC Model Weather Stations

SOD ID	Station Name	County	Elevation (feet)	SA WBAN ID	Name
010764	Bessemer (Alabama) 3 WSW	Jefferson	445	13876	Birmingham Intl Airport
010831	Birmingham Intl Airport	Jefferson	615	13876	Birmingham Intl Airport
010957	Boaz, Alabama	Marshall	1070	13876	Birmingham Intl Airport
013655	Hanceville, Alabama	Cullman	530	13876	Birmingham Intl Airport
016121	Oneonta, Alabama	Blount	892	13876	Birmingham Intl Airport
016246	Palmerdale, Alabama	Jefferson	720	13876	Birmingham Intl Airport
016478	Pinson, Alabama	Jefferson	608	13876	Birmingham Intl Airport
018648	Walnut Grove, Alabama	Etowah	850	13876	Birmingham Intl Airport

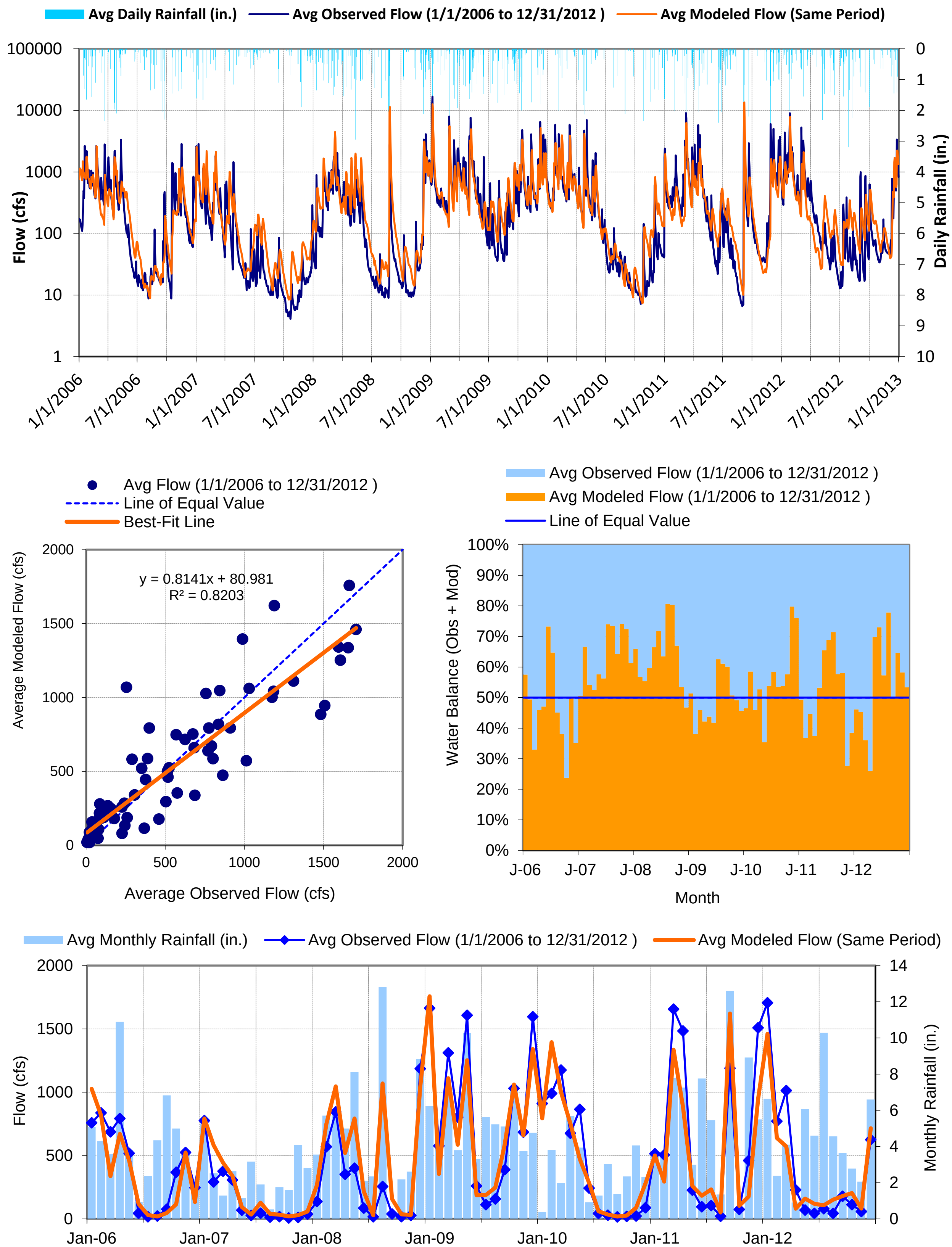
5.2.4 Hydrology Calibration

The LSPC watershed model was used to predict in-stream tributary flows in the Locust Fork watershed. The output from the LSPC model consisted of sub-watershed flows and concentrations. Calibration of the model was accomplished by comparing the LSPC simulated daily flow output to measured daily flow data at four USGS realtime stream flow stations in the Locust Fork watershed during the calibration period of January 1, 2007 through December 31, 2012. The table below lists the USGS stations in the Locust Fork watershed used to calibrate hydrology. An example of the results from the hydrology model calibration have been provided on the following page.

Table 5.2.4.1 LSPC Watershed Hydrology Calibration Stations

Agency	Site Number	Site Name
USGS	2455000	LOCUST FORK NEAR CLEVELAND, AL.
USGS	2456500	LOCUST FORK AT SAYRE, AL.
USGS	2457000	FIVEMILE CREEK AT KETONA AL
USGS	2458600	VILLAGE CREEK NEAR DOCENA, ALABAMA

Figure 5.2.4.1 Example of Hydrology Calibration - USGS 02455000 Observed vs. Modeled Flow



5.2.5 Water Quality Calibration

The LSPC watershed model was used to simulate the following water quality parameters:

- Dissolved Oxygen (DO)
- Temperature
- Total Phosphorus (TP)
- Total Nitrogen (TN)
- Total Suspended Solids (TSS)
- 5-day Carbonaceous Biochemical Oxygen Demand (CBOD5)

Calibration of the water quality model was accomplished by comparing the LSPC simulated daily output to measured water quality data at ten sampling stations in the Locust Fork watershed during the calibration period of January 1, 2007 through December 31, 2012. The calibration stations were selected based upon the availability of sufficient data and also the types of land use conditions present in the watershed. The table below lists the ADEM monitoring stations in the Locust Fork watershed used to calibrate water quality. The map on the following page illustrates the location of the calibration stations in the Locust Fork watershed, and the graphs provide an example of the LSPC calibration efforts.

Table 5.2.5.1 LSPC Watershed Water Quality Calibration Stations

Station ID	Latitude	Longitude	Description	Years Sampled
FM-1A	33.60694	-86.85972	Five Mile Creek at CR 77 near Upper Coalburg	2007
FMCJ-1A	33.58893	-86.77071	Five Mile Cr DS of Springdale Rd just DS of Confluence of Unnamed Tributary	2007
FM-2	33.61111	-86.88555	Five Mile Creek on Republic Rd (CR 67)	2006, 2007, 2008, 2009, 2010,2011, 2012
FMCJ-1B	33.60191	-86.75527	Five Mile Creek at State Highway 79 (near Ketona)	2007, 2008, 2009, 2010,2011, 2012
LFKB-1	34.02369	-86.57333	Locust Fork at ALA HWY 231	2008, 2012
LFKB-2	33.88849	-86.69531	Locust Fork at Armston Loop/Center Springs Rd (Vaughns Bridge)	2012
LFKB-8	33.80931	-86.80075	Locust Fork at Warrior-Kimberly Road	2008, 2012
LFKJ-3	33.74402	-86.91852	Locust Fork at Co Rd 77 "Hewitt Bridge"	2012
VI-3	33.54797	-86.92566	Village Cr at Jefferson Co Rd 65	2007, 2008, 2009, 2010,2011, 2012
VLGJ-5	33.62729	-87.05333	Village Creek on CR 45 at Power Plant nr West Jefferson	2006, 2007, 2008, 2009,2010, 2011, 2012

Figure 5.2.5.1 LSPC Locust Fork Watershed Calibration Stations

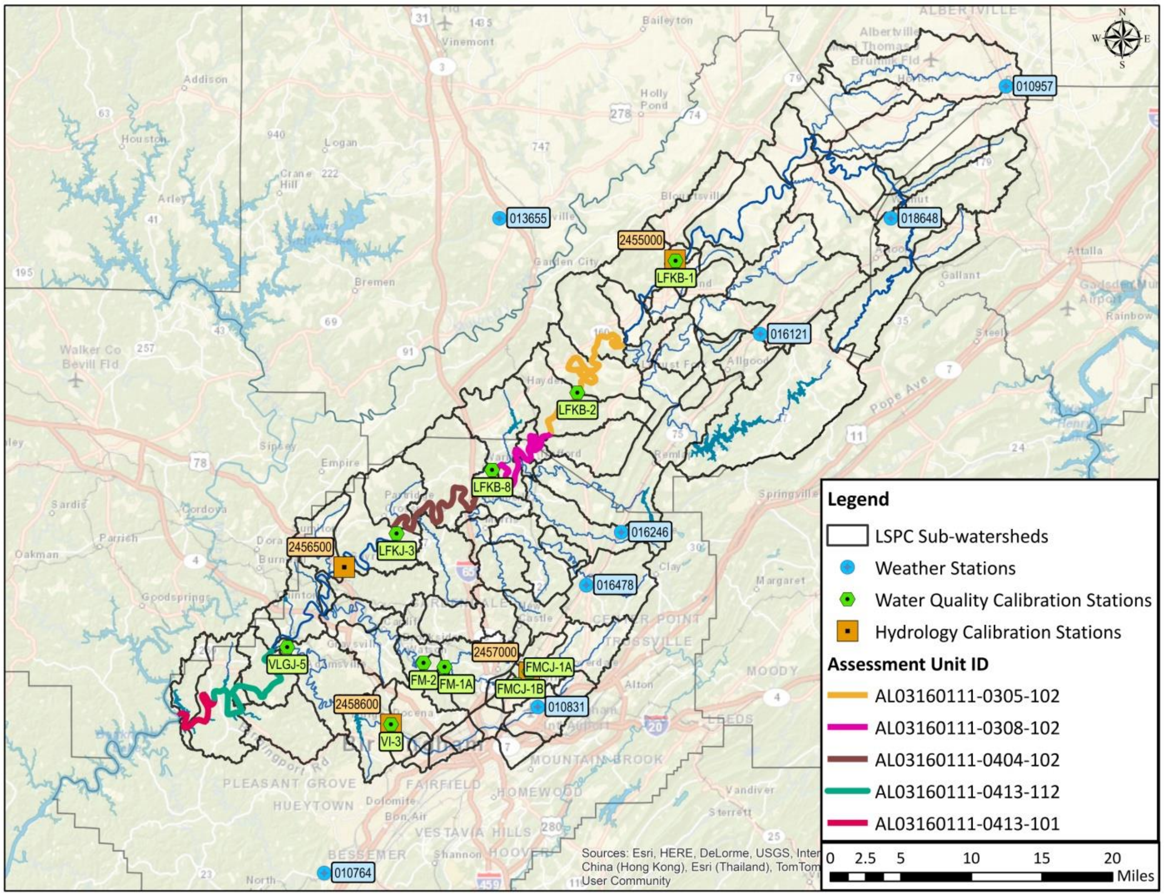


Figure 5.2.5.2 LSPC Calibration – Modeled vs. Observed Temperature (C) at FM-2

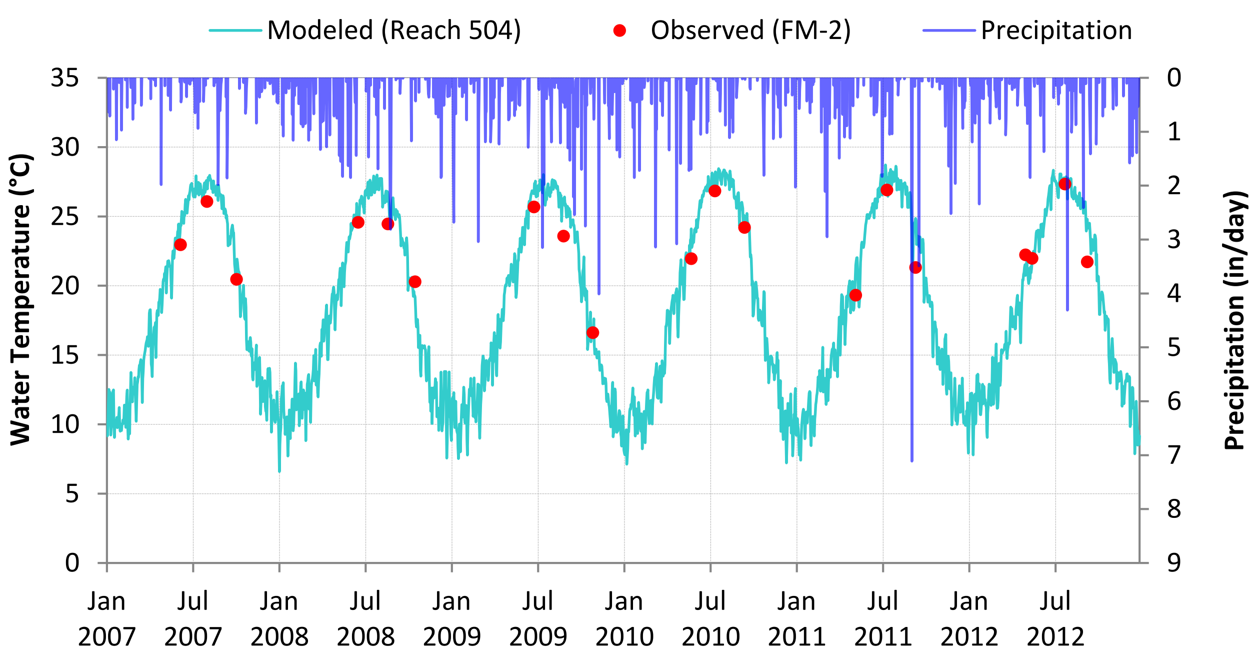


Figure 5.2.5.3 LSPC Calibration – Modeled vs Observed Total Nitrogen (mg/l) at FM-2

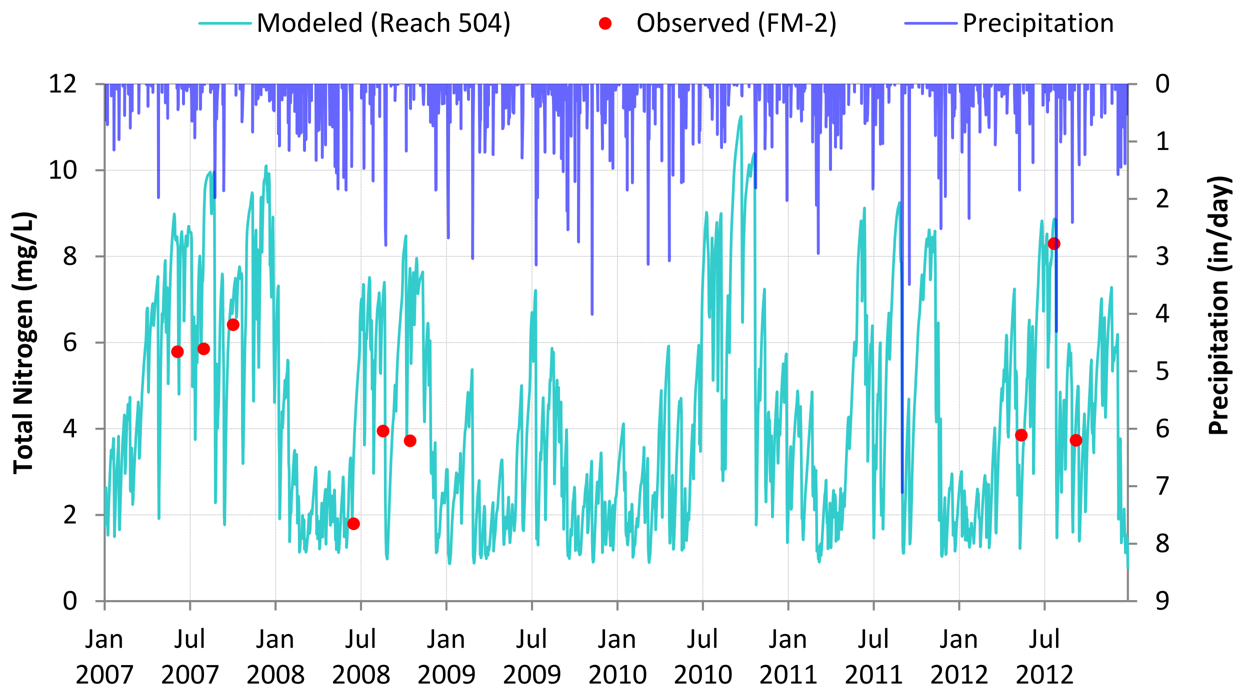
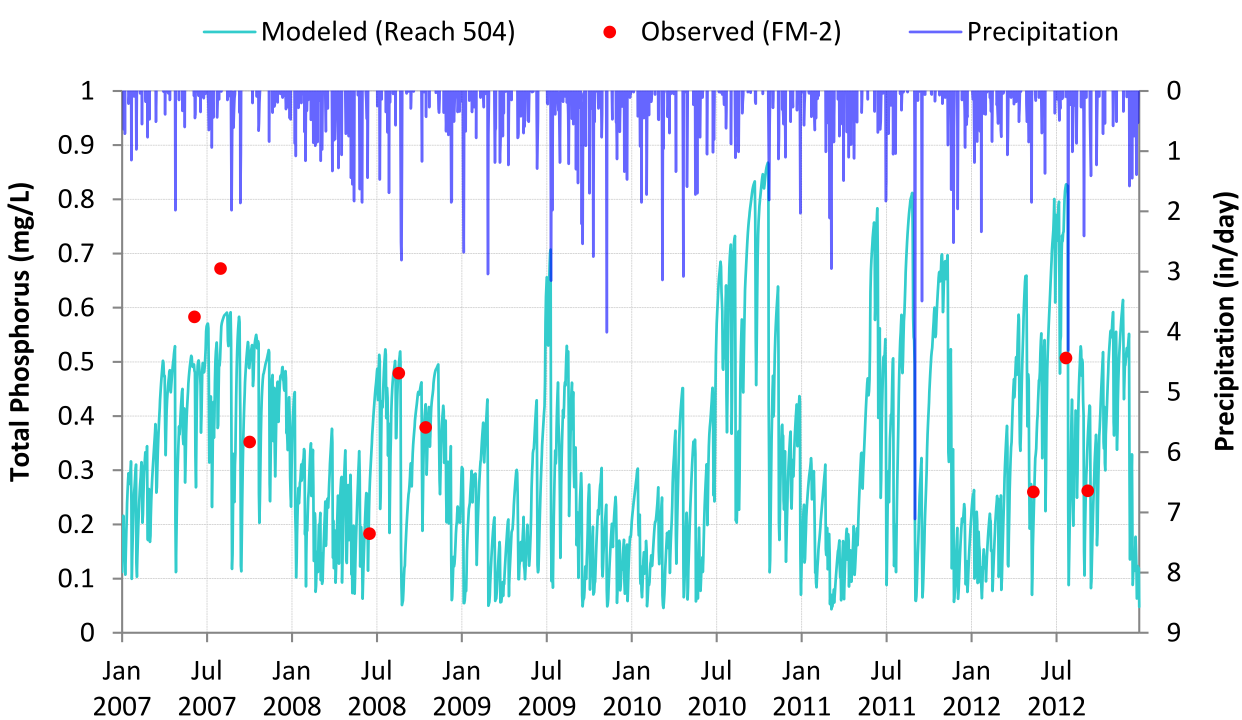


Figure 5.2.5.4 LSPC Calibration – Modeled vs. Observed Total Phosphorus (mg/l) at FM-2



5.3 Environmental Fluid Dynamics Code (EFDC) Model

The EFDC model was used to simulate the hydrodynamic conditions in the Bankhead reservoir and also the non-wadeable tributary embayment segments of the Locust Fork and the Mulberry Fork. The LSPC model output was linked and utilized as input boundary conditions for the EFDC model by providing daily flows and temperatures for both the tributaries boundaries and the adjacent sub-watersheds to Bankhead reservoir and the non-wadeable segments of the Locust Fork and Mulberry Fork. The EFDC model output was linked and used as input for the WASP model.

The EFDC modeled area is characterized by a series of connected computational grid cells that define the geometry of the simulated extent. The intention of the computational grid cell is to accurately depict the ambient geometry of the waterbody at that specific location, including the width, length, and depth. Bathymetry data provided by the U.S. Army Corps of Engineers (USACE) was utilized when generating the grid cells. The Bankhead reservoir EFDC computational grid area consists of a total of 3636 grid cells: 606 horizontal grid cells and 6 vertical layers. See the figures below for an illustration of the EFDC computational cells used to simulate the Bankhead Reservoir and the non-wadeable segments of the Locust Fork.

Figure 5.3.1 EFDC Computation Grid Extent on Bankhead Reservoir

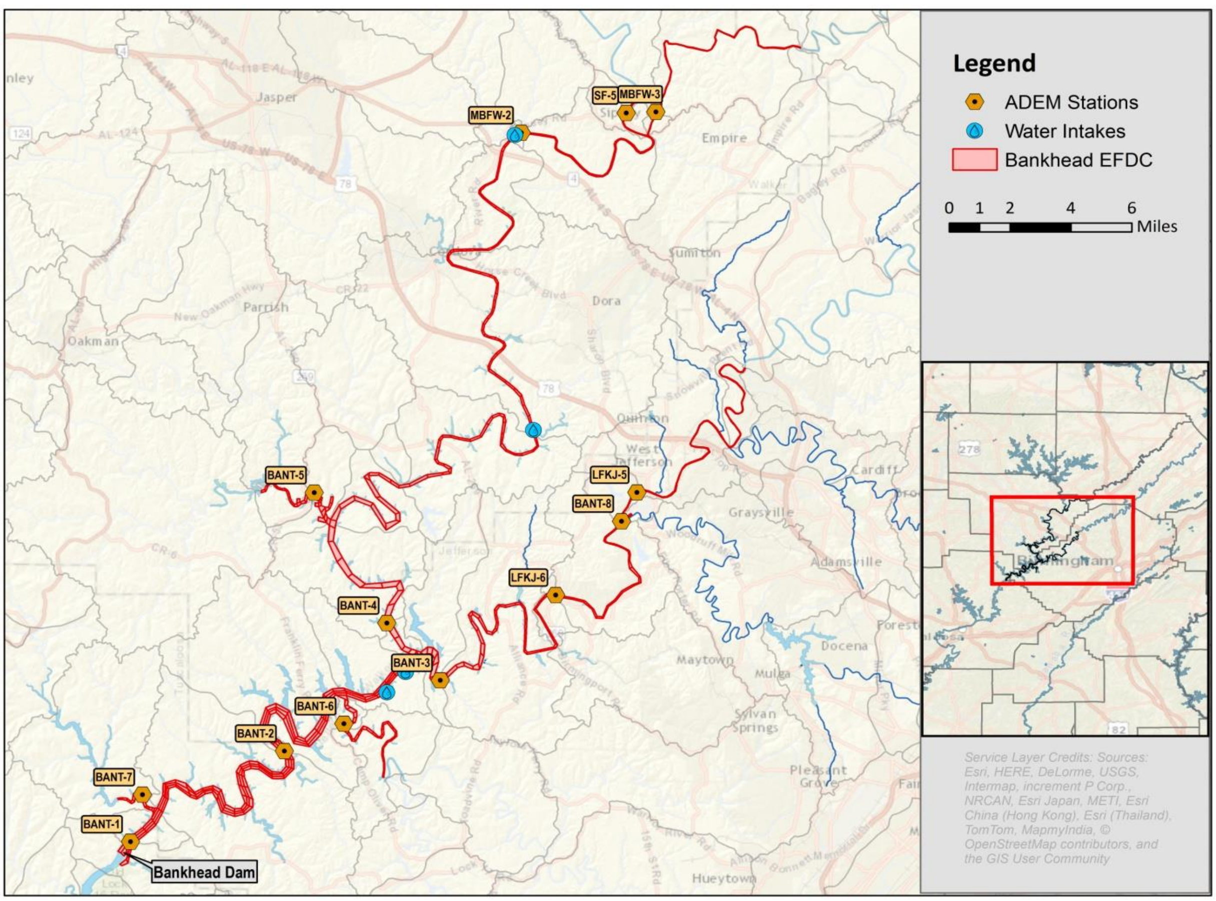
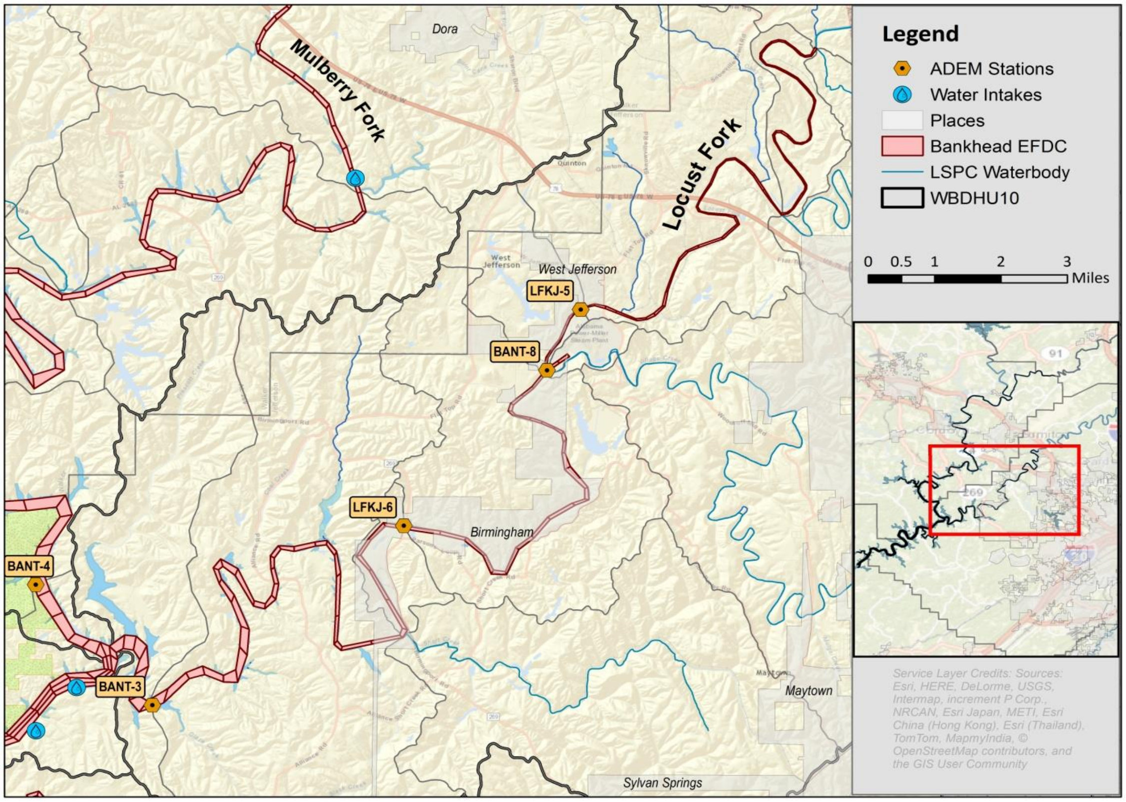


Figure 5.3.2 EFDC Computation Grid Extent on Locust Fork Tributary Embayment



Surface water withdrawal sources in the Bankhead Reservoir were also included in the EFDC model. The table below provides information regarding the six surface water withdrawal sources in the Bankhead Reservoir:

Table 5.3.1 Bankhead Reservoir Surface Water Withdrawal Sources

Permit	System Name	Source Water	Average Withdrawal (MGD)	Plant Capacity Withdrawal (MGD)
AL0000738	Birmingham Water Works and Sewer Board	Mulberry Fork	26.41[a]	60
AL0001782	Bessemer (G.U.S.C.)	Black Warrior River	10.17[a]	18
AL0000763	Warrior River Water Authority	Mulberry Fork	3.04[a]	6
AL0001336	Jasper Utilities Board	Mulberry Fork	10.49[a]	18
AL0002909	Alabama Power Company – Gorgas Steam Plant	Mulberry Fork	837.71[b,c]	946.44
AL0027146	Alabama Power Company – Miller Steam Plant	Mulberry Fork	30.02[b,d]	43.2

a - daily
b - monthly

c. Withdrawal water utilized for once-through cooling and returned back to the river. In EFDC model, all withdrawal water is discharged back to the Black Warrior River in the immediate downstream cell.
d. Withdrawal water pumped from the Mulberry Fork is stored in a holding pond. From the holding pond, makeup and service water is gravity fed to the plant located on the Locust Fork as needed. Estimates of water returns to the Locust Fork were assumed based upon a 20% return rate of the withdrawal water.

5.3.1 EFDC Model Calibration

The output for the EFDC model consists of water surface elevations, temperatures, volumes and velocities. Hydrodynamic calibration of the EFDC model was accomplished by comparing the model predicted stage height and temperature profiles to actual measured data during the calibration period of January 1, 2007 through December 31, 2012. The figures below provide an example of the calibrations results.

Figure 5.3.1.1. Comparison of water surface elevation between USGS 02462500 vs. modeled

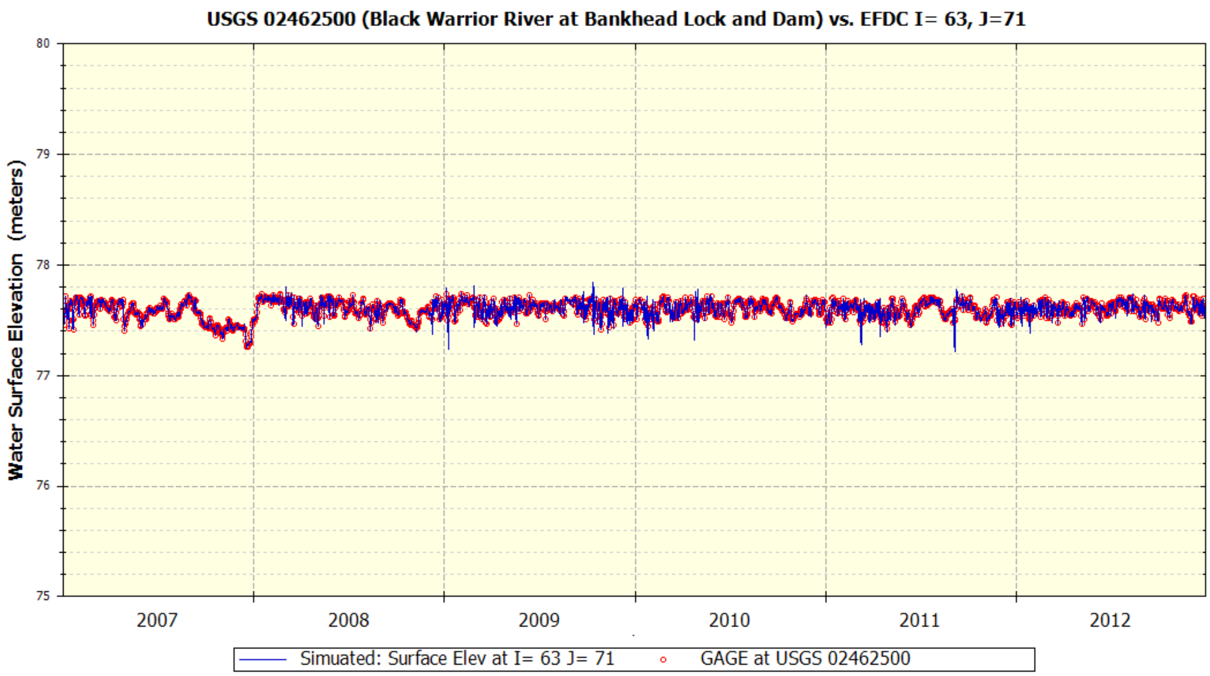
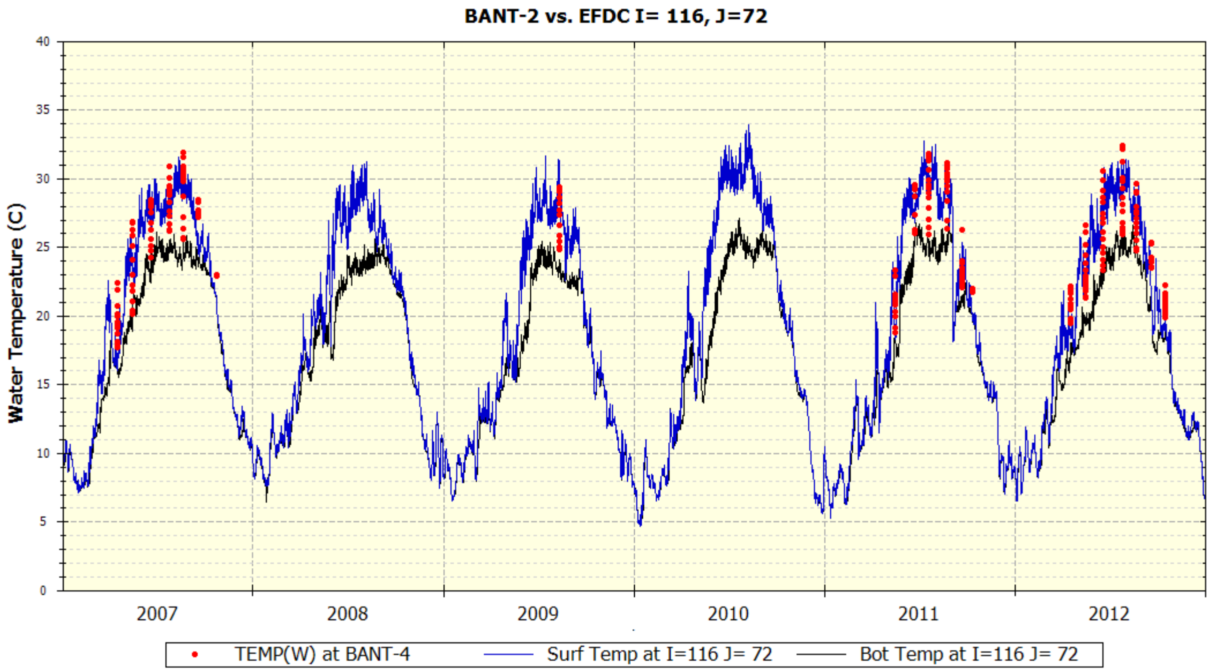


Figure 5.3.1.2 Comparison of station BANT-2 water temperature vs modeled temperature



5.4 Water Quality Analysis Simulation Program (WASP) Model

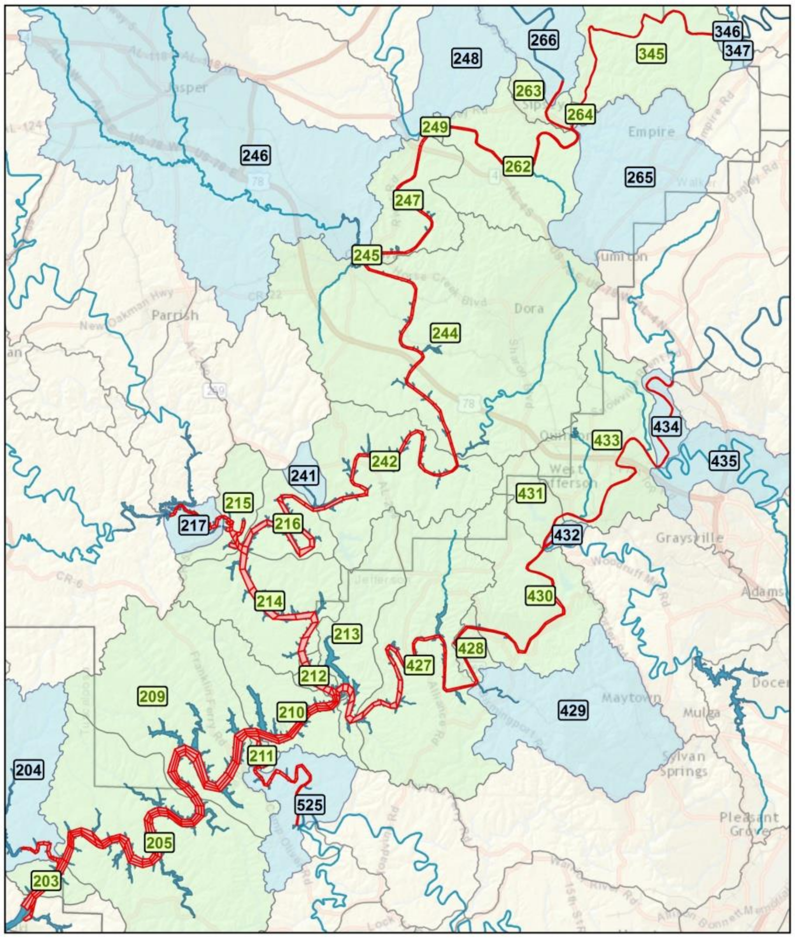
WASP 7.52 is a dynamic water quality model that was used to simulate water quality in the Bankhead Reservoir and the non-wadeable segments of the Locust Fork. The WASP eutrophication model was used to simulate the following state variables in the Bankhead Reservoir and the non-wadeable segment of the Locust Fork:

- Ammonia (mg/l)
- Organic Nitrogen (mg/l)
- Organic Phosphorus (mg/l)
- Dissolved Oxygen (mg/l)
- Total Suspended Solids (mg/l)
- Nitrate-Nitrite (mg/l)
- Orthophosphate (mg/l)
- Chlorophyll-a (µg/l)
- Biochemical Oxygen Demand (mg/l)
- Temperature (˚C)

The WASP model is directly coupled to the hydrodynamic loading output from both the LSPC and EFDC models. The pollutant concentrations from the LSPC model output are directly linked to the WASP model as boundary conditions, providing the pollutant concentrations from the tributaries and the sub-watersheds that connect directly to the EFDC computational grid extent. The output from the EFDC model was also linked to WASP in order to provide the hydrodynamic data (temperature, volume, and velocities).

The figure below illustrates the linkage between the output from the LSPC sub-watersheds and the EFDC computational grid cells utilized by the WASP model. The LSPC "RO" sub-watersheds shown in blue represent the modeled instream flow from the major tributaries in the watershed flowing directly to the Bankhead Reservoir, simulated by the EFDC computational grid. The LSPC "PERO" sub-watersheds shown in green represent the modeled overland flow from the local watersheds immediately adjacent to the computational grid. A total of fourteen major tributaries in the Bankhead Lake watershed were simulated using the LSPC model on a daily time step and linked directly to the EFDC (flows and temperature) and WASP (pollutant concentrations) models.

Figure 5.4.1 WASP Model Boundary Inputs



LSPC Sub-watershed ID	EFDC Cell (I,J)	Type of watershed flow	Waterbody
204	(66, 86)	RO	Big Yellow Creek
217	(126, 100)	RO	Lost Creek
241	(138, 72)	RO	Baker Creek
246	(202, 72)	RO	Cane Creek
248	(232, 72)	RO	Blackwater Creek
265	(271, 72)	RO	Old Town Creek
266	(285, 72)	RO	Sipsey Fork
346	(272, 20)	RO	Mulberry Fork
347	(272, 21)	RO	Sloan Creek
429	(147, 70)	RO	Short Creek
432	(177, 67)	RO	Village Creek
434	(255, 70)	RO	Locust Fork
435	(216, 70)	RO	Fivemile Creek
525	(102, 36)	RO	Valley Creek
203	(65, 72)	PERO	Overland
205	(80, 72)	PERO	Overland
209	(98, 72)	PERO	Overland
210	(106, 72)	PERO	Overland
211	(102, 64)	PERO	Overland
212	(114, 72)	PERO	Overland
213	(115, 70)	PERO	Overland
214	(123, 72)	PERO	Overland
215	(126, 76)	PERO	Overland
216	(129, 72)	PERO	Overland
242	(153, 72)	PERO	Overland
244	(189, 72)	PERO	Overland
245	(200, 72)	PERO	Overland
247	(227, 72)	PERO	Overland
249	(234, 72)	PERO	Overland
262	(249, 72)	PERO	Overland
263	(279, 72)	PERO	Overland
264	(272, 67)	PERO	Overland
345	(272, 31)	PERO	Overland
427	(125, 70)	PERO	Overland
428	(149, 70)	PERO	Overland
430	(161, 70)	PERO	Overland
431	(181, 70)	PERO	Overland
433	(200, 70)	PERO	Overland

5.4.1 WASP Model Calibration

The WASP model was calibrated by comparing the model predicted state variables described on the previous page to actual measured instream water quality data collected by the Department during the calibration period of January 1, 2007 through December 31, 2012. Calibration of the WASP model was accomplished by adjusting the state variable rates (growth, decay, mineralization, nitrification, etc.) until the predicted concentrations closely matched those of measured values. Successful calibration of the WASP model was considered to be achieved when the model was accurately simulating the fate and transport of nutrients within the reservoir in addition to the uptake by phytoplankton. The output variable chlorophyll-a is utilized by WASP as a surrogate parameter to represent the aggregate measure of phytoplankton biomass within the model.

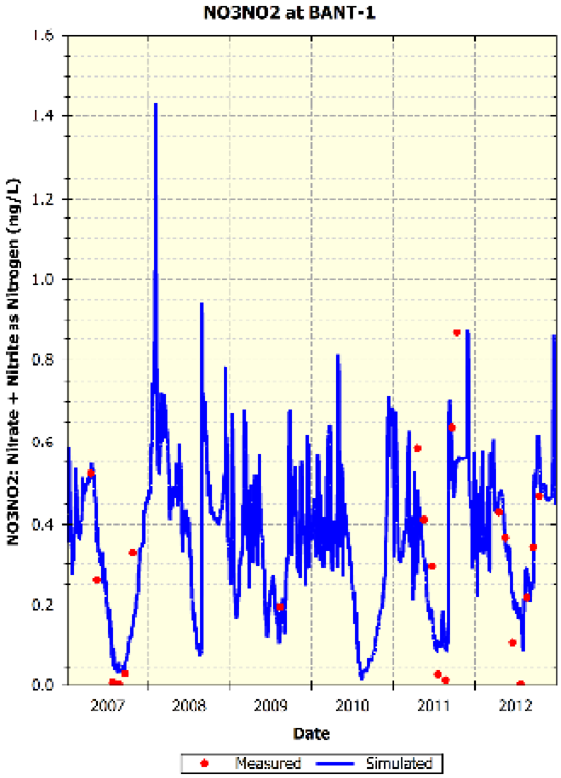
The table below lists the Department's Rivers & Reservoir Monitoring Program (RRMP) stations in the Bankhead reservoir that were utilized in calibration of the WASP model. Specifically, model calibration at stations BANT-1, BANT-2, BANT-3, and BANT-4 was heavily weighted due to their locations within the reservoir and also the availability of data. Refer to Figure 5.3.1 for an illustration of the stations in the Bankhead Reservoir.

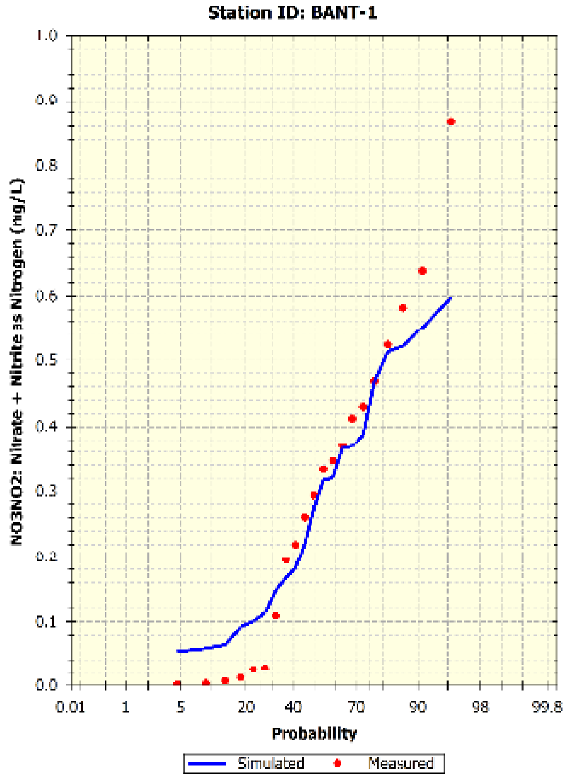
Table 5.4.1.1 WASP Water Quality Calibration Stations

Station ID	Latitude	Longitude	Station Description
BANT-1	33.46637	-87.34811	Bankhead Lake – Lower reservoir. Deepest point, main river channel, dam forebay.
BANT-2	33.50949	-87.26372	Bankhead Lake – Mid-reservoir. Deepest point, main river channel, mid-reservoir. Approximately 0.5 miles upstream of Little Shoal Creek confluence.
BANT-3	33.54480	-87.17498	Bankhead Lake – Locust Fork. Deepest point, main river channel, Locust Fork. Approximately 1.5 miles upstream of Mulberry, Locust confluence.
BANT-4	33.57322	-87.20552	Bankhead Lake – Mulberry Fork. Deepest point, main river channel, Mulberry Fork. Approximately 1.5 miles upstream of Mulberry, Locust confluence.
BANT-5	33.63799	-87.24702	Lost Creek embayment deepest point, main creek channel. Approximately 0.5 miles downstream of Walker Co. Rd. 53 bridge.
BANT-6	33.52312	-87.22987	Valley Creek embayment deepest point, main creek channel. Approximately 1.0 miles upstream of confluence with Warrior River.
BANT-7	33.48760	-87.34430	Big Yellow Creek embayment, approximately 1 mile upstream of confluence with Warrior River.
BANT-8	33.62280	-87.07060	Village Creek embayment approximately 0.5 miles upstream of confluence with Warrior River.
LFKJ-5	33.63653	-87.06124	Locust Fork at Co. Rd 45 Porter Road.
LFKJ-6	33.58726	-87.10933	Locust Fork at Co. Rd 269 Attwood Ferry Bridge.
MBFW-2	33.81711	-87.12932	Mulberry Fork deepest point of the main river channel approximately 1 mile north of Hwy 78 bridge
MBFW-3	33.82755	-87.05238	Mulberry Fork, approximately 1 mile or so upstream of the confluence with the Sipsey Fork. Most importantly, just upstream enough to avoid any influence from the Sipsey Fork.
SF-5	33.82698	-87.06931	Sipsey Fork, approximately 1 mile upstream of the confluence with the Mulberry Fork.

Figure 5.4.1.1 provides an illustration of the WASP calibration results.

Figure 5.4.1.1 WASP Calibration Example

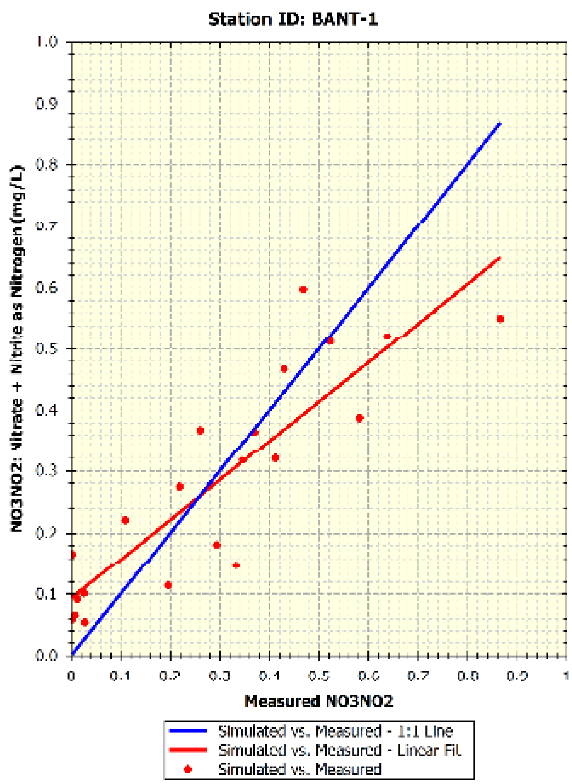




Calibration Statistics

Date Range: 1/3/2007 - 12/30/2012

Statistic	Measured	Simulated
Station: BANT-1; Parameter: NO3NO2		
Count:	21	21
Mean:	0.292	0.280
Median:	0.334	0.317
Std Dev:	0.243	0.178
Min:	0.002	0.054
Max:	0.866	0.597
5 %tile:	0.002	0.054
10 %tile:	0.004	0.061
90 %tile:	0.627	0.545
95 %tile:	0.843	0.593
Coef of Det (R^2):	0.76	
Mean Abs Error:	0.097	
RMS Error:	0.121	
Norm RMS Error:	0.351	
Index of Agreement:	0.91	



Chapter 6.0 TMDL Development for the Locust Fork Watershed

6.1 Applicable Water Quality Criterion

The results of the Department's monitoring efforts in the Locust Fork watershed indicate elevated concentrations of nutrients along the wadeable mainstem reaches of the Locust Fork. Furthermore, elevated concentrations of nutrients have also been observed on several of the major tributaries to the Locust Fork, specifically Village Creek and Fivemile Creek. Nutrients such as phosphorus and nitrogen are essential elements to aquatic life, but can be undesirable when present at sufficient concentrations to stimulate excessive plant growth. Even though these pollutants are generally considered to be nontoxic (the exception being un-ionized ammonia toxicity to aquatic life), they can impact aquatic life due to their indirect effects on water quality, either when in overabundance or when availability is limited.

ADEM's water quality criteria applying to nutrients are narrative; therefore a numerical translator is needed to define the TMDL target. Lakes are complex systems influenced by morphometry, climate, and watershed characteristics. The assignment of specific numeric nutrient criteria to address both causal and response variables associated with nutrient over-enrichment that will be considered protective of the designated uses of the waterbody is a challenging task. According to ADEM's Nutrient Criteria Implementation Plan (ADEM, 2011), chlorophyll-a (response indicator) has been chosen as the primary variable for addressing cultural eutrophication and will be used as the primary tool for protecting designated uses of lakes and reservoirs from nutrient over-enrichment. Chlorophyll-a was chosen as the candidate variable because of its wide acceptance among federal/state agencies, limnologists and scientists as being a good surrogate for estimating phytoplankton biomass and because it provides the most direct indication of how nutrients are impacting a lake's designated uses. Chlorophyll-a is also considered a good early indicator of nutrient enrichment and is relatively easy and inexpensive to collect and analyze.

Currently, the Department has already established a chlorophyll-a criterion in the Bankhead Lake forebay. ADEM's Administrative Code 335-6-10-.11 reads as follows:

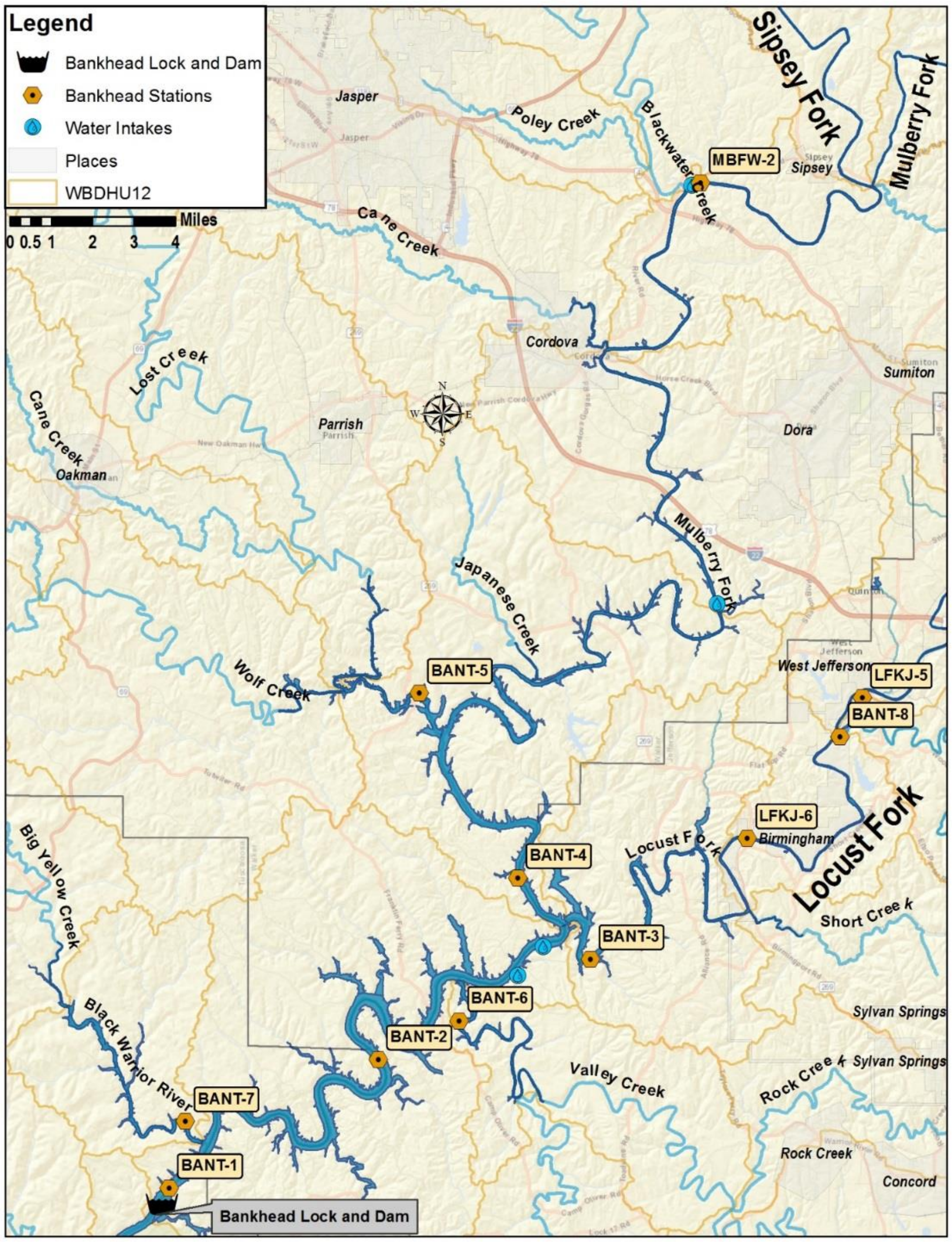
335-6-10-.11 Water Quality Criteria Applicable to Specific Lakes.
Bankhead Lake: those waters impounded by John Hollis Bankhead Lock and Dam on the Black Warrior River. The lake has a surface area of 9,200 acres at full pool.

(i) Chlorophyll-a (corrected, as described in *Standard Methods for the Examination of Water and Wastewater, 20th Edition*, 1998): the mean of the photic-zone composite chlorophyll-a samples collected monthly April through October shall not exceed 16 μg/l, as measured at the deepest point, main river channel, dam forebay.

The aforementioned chlorophyll-a criterion is applicable at station BANT-1 and is expected to be protective of the Bankhead Lake forebay area and also a significant portion of the mainstem reservoir upstream of the dam. However, Bankhead Lake is a very non-uniform, complex system.

Bankhead Lake is not considered a "run-of-the-river" reservoir. The primary source of water "feeding" the lake system originates from numerous tributaries in the watershed. The impounded waters of Bankhead Lake encompass the following three significant tributaries, or "forks": Sipsey Fork, Mulberry Fork, and Locust Fork. Each tributary "fork" drains a very large watershed area and the cumulative flow from the three forks to the Bankhead reservoir system constitutes the majority of the water flowing into the reservoir. In order to address such a complex system, the Department has continued tributary embayment sampling as a part of the Rivers & Reservoir Monitoring Program (RRMP). The figure below illustrates the three major "forks" of Bankhead Lake and also depicts the Locust Fork reservoir embayment stations.

Figure 6.1.1 Bankhead Lake and major tributaries



As previously mentioned in the Data Analysis section, the negative effects associated with the elevated concentrations of nutrients observed in the wadeable segments of the Locust Fork, and several major tributaries to the Locust Fork, are being expressed further downstream in the tributary embayment segment. In the non-wadeable tributary embayment segment of the Locust Fork, favorable conditions for the uptake of available nutrients in the water column, such as longer retention times and more available sunlight reaching the water surface leading to increased water temperatures, are greatly improved compared to conditions in the wadeable segments. Based on sampling conducted as a part of the Department's RRMP, water quality data obtained at the Locust Fork embayment stations LFKJ-6 and BANT-3 indicate nutrient over-enrichment conditions are present in the tributary embayment of the Locust Fork. Evidence of the nutrient over-enrichment conditions observed in the Locust Fork embayment are described below as an excerpt from the Department's 2012 §303(d) fact sheet, which served as the basis for this segment's inclusion on the §303(d) list:

"Records at ADEM Station LFKJ-6 from 2005- 2011 show dissolved oxygen concentrations ranging from 4.6 mg/L to 18.8 mg/L. The median pH value during this period of record was 7.9 s.u. and the maximum value was 9.3 s.u. These enriched conditions are most likely caused by high Nitrogen and/or Phosphorus concentrations. During this time period the median Total Nitrogen concentration was 3.06 mg/L with a maximum concentration of 17.38 mg/L. The median Total Phosphorus concentration was 0.07 mg/L with a maximum value of 0.17 mg/L. In addition, a maximum chlorophyll-a value of 98.70 µg/L was recorded. Chlorophyll-a values as high as 48.59 µg/L were measured at a downstream station, BANT-3 as well."

Since the negative effects associated with nutrient over-enrichment are being observed in the tributary embayment and not in the wadeable segments of the Locust Fork, the Department has decided to establish a target for water quality improvement in the tributary embayment. Therefore, for the basis of this TMDL, the Department will identify a target growing season mean chlorophyll-a concentration in the Locust Fork tributary embayment. The chlorophyll-a target is interpreted to be the mean chlorophyll-a concentration of the photic zone composite samples collected monthly from April through October.

As previously mentioned, anthropogenic sources in the Locust Fork watershed are considered the origin of the excessive nutrients that are externally introduced into the Locust Fork aquatic eco-system. In order to address those sources in the watershed, hydrodynamic water quality models were utilized to better understand the link between nutrients, the sources, their effects on algal productivity, and which nutrient (nitrogen and/or phosphorus) will be the most effective to control in order to achieve the selected chlorophyll-a target and protection of downstream uses. The models will be used to evaluate the extent of necessary nutrient reductions from the sources in the watershed to achieve the targeted chlorophyll-a concentration.

6.1.1 Chlorophyll-a Target Development

Selection of an appropriate numeric chlorophyll-a target in the Locust Fork tributary embayment was based upon careful consideration of the following factors: available Department- collected water quality data, existing designated uses, and downstream use protection.

- **Available Data**
  - As a part of the RRMP, the Department has routinely collected water quality data on the Bankhead reservoir mainstem and also on the major tributary embayments to Bankhead Lake. The Department has accumulated an extensive catalog of historical water quality data from healthy tributary embayments on Bankhead Lake. Table 6.1.1.1 below depicts the evaluation of the available chlorophyll-a dataset from Bankhead Lake tributary embayment stations BANT-5 in Lost Creek and BANT-7 in Big Yellow Creek in order to provide additional insight into the expected range of chlorophyll-a concentrations from waterbodies that are meeting their existing designated uses in regards to nutrient enrichment. Refer to Figure 6.1.1 for a map depicting the relative locations of the stations within the reservoir.

Table 6.1.1.1 Bankhead Tributary Embayment Chlorophyll-a data

BANT-5 Lost Creek Embayment			BANT-7 Big Yellow Creek Embayment		
Year	**Samples per year**	**Growing Season Average Chlorophyll-a (µg/l)**	**Year**	**Samples per year**	**Growing Season Average Chlorophyll-a (µg/l)**
1998	7	9.5	1998		N/A
2002	7	13.7	2002	7	12.8
2007	7	14.7	2007	7	16.6
2012	7	7.9	2012	7	11.7

Average	11.4	**Average**	13.7
75th %ile	14.0	**75th %ile**	14.7
90th %ile	14.4	**90th %ile**	15.9

- **Designated Uses**
  - The existing designated uses for the impaired reach of the Locust Fork tributary embayment segment include Public Water Supply (PWS), Swimming (S), and Fish & Wildlife (F&W). Therefore, when considering an appropriate chlorophyll-a target in conjunction with the existing Public Water Supply use classification, it is important to consider the adverse effects associated with excessive algae growth that can potentially contaminate source water.

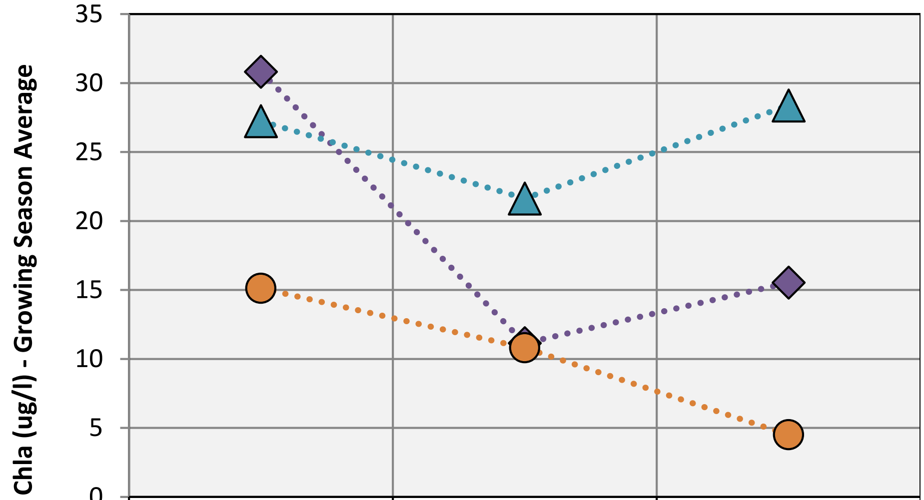
- Similarly, when considering an appropriate chlorophyll-a target in conjunction with the existing Swimming use classification, those water conditions associated with swimming and other whole body contact water sports, like water clarity for instance, must also be considered.
- To determine what constitutes healthy conditions in various types of reservoirs and how trophic gradients relate to the Fish and Wildlife use attainment, the Department utilized research conducted by Dr. David Bayne at Auburn University. This research examines how the quality of fisheries correlates to varying trophic conditions in Alabama reservoirs. The results of Dr. Bayne's research indicated a growing season average chlorophyll-a criteria of 20 µg/l should be considered as the upper end of a range that is protective of a balanced sport fishery (Maceina, M.J. et al).

- **Protection of Existing Standards & Downstream Uses**

  - In determination of an appropriate chlorophyll-a target, consideration must also be given to the existing water quality standards of the downstream waterbodies to ensure that those standards are both attained and also maintained. The Department concluded the applicable chlorophyll-a target in the Locust Fork tributary embayment should not be more stringent than the existing growing season average chlorophyll-a criteria of 16 µg/l as measured at station BANT-1 in the Bankhead lake forebay.

A review of WASP modeling output and Department-collected water quality data was completed in order to select an appropriate location, or compliance point, for the chlorophyll-a target. The graph below illustrates the measured growing season average chlorophyll-a concentrations from three of the Department's existing Locust Fork tributary embayment stations collected during sample years 2002, 2007, and 2012. Based upon an assessment of the historical datasets, the highest measured growing season average chlorophyll-a concentrations are usually observed in the Locust Fork embayment at station BANT-3.

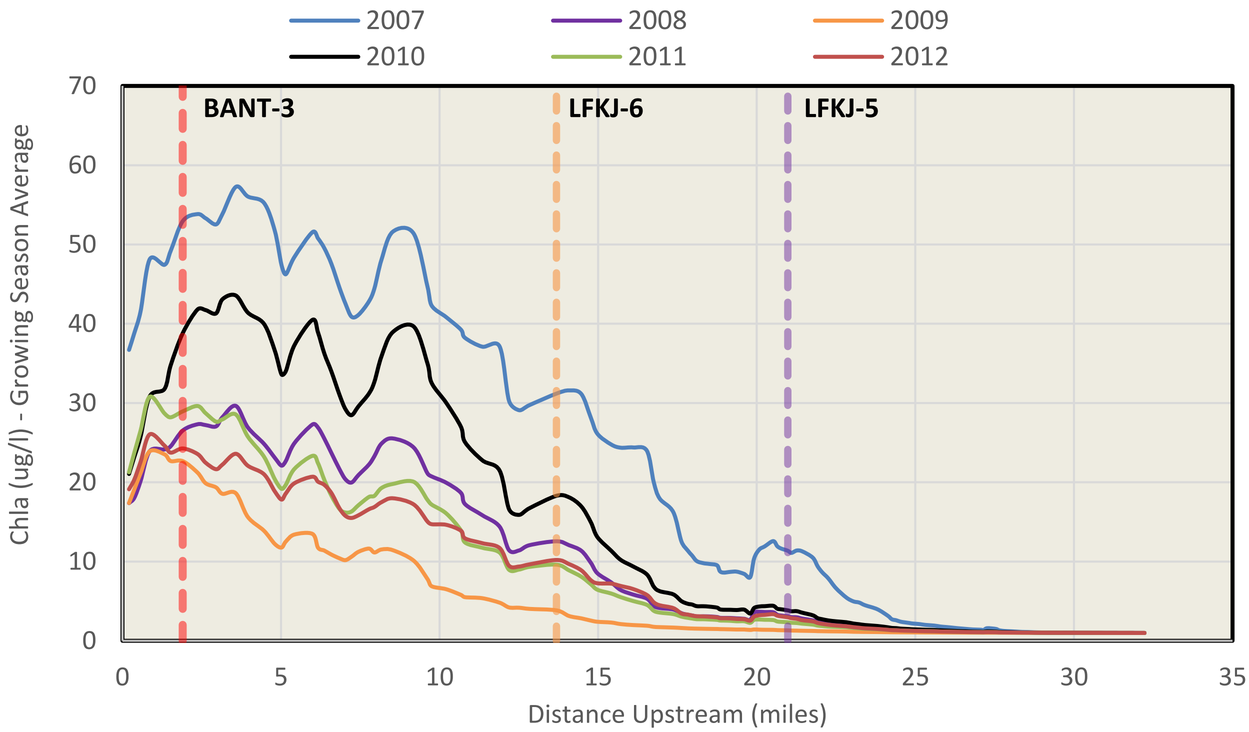
Figure 6.1.1.1 Locust Fork Embayment Chlorophyll-a data



	BANT-3	LFKJ-6	LFKJ-5
2002 Average	30.83	11.14	15.53
2007 Average	27.24	21.63	28.38
2012 Average	15.12	10.80	4.5

The figure below depicts a longitudinal profile of the predicted growing season chlorophyll-a concentrations from the WASP permit condition modeling scenario for each year in the model simulation period. The vertical bars denote where the Department's existing stations are located in relation to river miles upstream of the Locust Fork mouth. Based upon an assessment of the WASP output data, the greatest chlorophyll-a concentrations are predicted to occur in the downstream segments of the Locust Fork, approximately 3-4 miles upstream of the confluence with the Mulberry Fork. Predicted growing season chlorophyll-a concentrations steadily decrease progressing further upstream on the Locust Fork. Therefore, if the chlorophyll-a target is set at station BANT-3, the upstream chlorophyll-a concentrations are not expected to exceed the target concentration.

Figure 6.1.1.2 WASP Permit Condition Chlorophyll-a – Longitudinal Profile



The Department has concluded a growing season average (April – October) chlorophyll-a target of 18 µg/L will be established in the Locust Fork tributary embayment at station BANT-3. The Department believes the chlorophyll-a target of 18 µg/L applicable at the existing tributary embayment station BANT-3 will support the designated uses of the Locust Fork.

6.2 Limiting Nutrient Identification

In order to meet the instream chlorophyll-a target of 18 µg/L, the Department utilized the trio of linked water quality models to simulate how the chlorophyll-a concentrations in the Locust Fork embayment at station BANT-3 respond to nutrient reductions to both point sources and nonpoint sources in the watershed. The first step in this process was to identify the limiting nutrient in the system which would ultimately serve as the specific nutrient that is targeted for reduction. The limiting nutrient in an aquatic eco-system is considered to be the nutrient that is essential for plant growth but is available only in low enough concentrations to be "limiting" or preventing further growth of the species. Available EPA guidance indicates that in a freshwater system phosphorus is usually the key nutrient in regards to limiting productivity and controlling excessive algae growth (USEPA 2000). Furthermore, two additional lines of evidence, discussed below, were utilized in order to for the Department to identify phosphorus as the limiting nutrient in the Locust Fork tributary embayment to the Bankhead Reservoir. Therefore, the Department anticipates that a reduction to total phosphorus from sources in the watershed, without concurrent reductions to total nitrogen, will result in the attainment of the chlorophyll-a target of 18 µg/l.

6.2.1 Algal Growth Potential Test

The Algal Growth Potential Test (AGPT) measures the potential of an aquatic ecosystem to support the growth of algal biomass. The test is also instrumental in identifying the absence of which nutrient is preventing the further growth of more algae (i.e., the “limiting nutrient”). Since 1998, the Department has collected water quality samples for the AGPT from two stations directly on the Locust Fork – BANT-3 and LFKJ-5. The results of the AGPT (expressed as mean Maximum Standing Crop (MSC) dry weights of Selenastrum capricornutum in mg/L) and limiting nutrient status are illustrated in the table below. MSC values below 5 mg/L are considered to be protective in reservoirs and lakes; values below 20 mg/L MSC are considered protective of flowing streams and rivers. (Raschke and Schultz 1987).

Table 6.2.1.1 Locust Fork AGPT Results

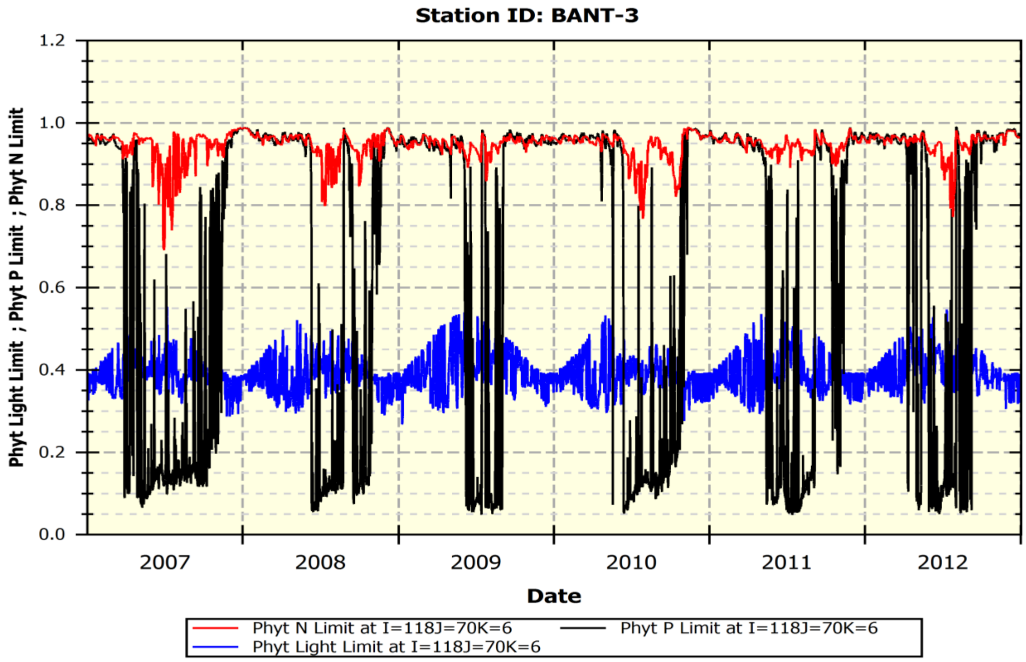
Station ID	Visit Date	Limiting Nutrient	AGPT MSC (mg/l)
BANT-3	8/25/1998	Phosphorus	24.74
BANT-3	8/21/2002	Phosphorus	15.91
BANT-3	6/19/2007	Phosphorus	2.34
BANT-3	7/25/2007	Phosphorus	3.44
BANT-3	8/21/2007	Nitrogen	9.53
BANT-3	8/22/2012	Phosphorus	39.24
LFKJ-5	6/19/2007	Phosphorus	12.19
LFKJ-5	7/26/2007	None	41.12
LFKJ-5	8/21/2007	Co-limiting	2.66

The results of the AGPT indicate that in the Locust Fork, total phosphorus can be considered the nutrient limiting the further growth of algal biomass in the water column. Furthermore, based upon the maximum standing crop values above the suggested value of 5 mg/l, the results indicate the potential for the incidence of nuisance algal blooms to occur in the Locust Fork embayment.

6.2.2 WASP Predicted Nutrient Limitation

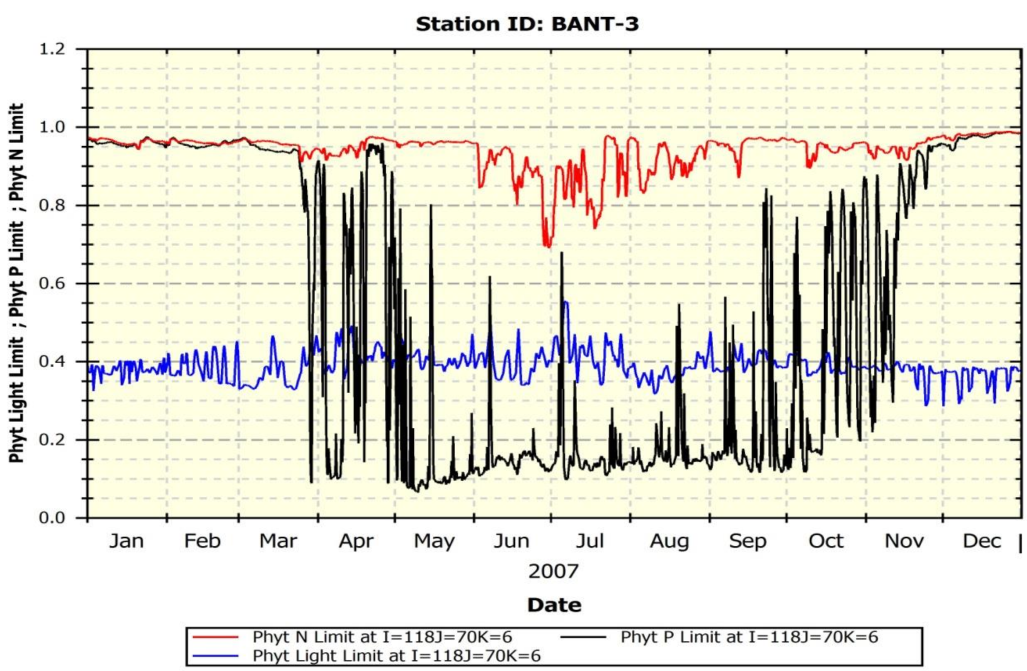
The results of the WASP model also indicate the algal biomass in the Locust Fork tributary embayment is phosphorus limited during the growing season. The figure below illustrates the calibrated WASP model-predicted time series limitations for nitrogen, phosphorus, and sunlight during the modeled period of January 1, 2007 to December 31, 2012 for the particular cell corresponding to station BANT-3. The values representing the limitation along the y-axis range from 0.0 to 1.0, with the limiting nutrient indicated by the lower values.

Figure 6.2.2.1 WASP Calibrated Model – BANT-3 Nutrient Limitation 2007-2012



The figure below highlights the calibrated WASP model-predicted time series limitations for nitrogen, phosphorus, and sunlight during the drought year of 2007.

Figure 6.2.2.2 WASP Calibrated Model – BANT-3 Nutrient Limitation 2007



6.3 Locust Fork Model Scenarios

6.3.1 Overview of Locust Fork Modeling Scenarios

The strategy behind utilizing the aforementioned calibrated dynamic water quality models (LSPC, EFDC, and WASP) in the Locust Fork TMDL development process is to have the capability to compare the results from several projected scenarios during the model simulation period of January 1, 2007 to December 31, 2012. The scenario simulations represent a combination of hypothetical NPDES permit requirements, specifically monthly average total phosphorus concentration based effluent limitations to point sources in the watershed, and proposed reductions to nonpoint source pollutant loading in the watershed that would ultimately achieve a growing season average chlorophyll-a target of 18 µg/L at the compliance point located at Locust Fork station BANT-3. This iterative process allows the Department to use the water quality models as a management tool to assess alternative combinations of waste load and load allocations that would most fairly, efficiently, and effectively establish the TMDL for the Locust Fork.

6.3.2 Locust Fork Scenario Descriptions

A series of model runs were examined using the Locust Fork water quality models (LSPC, EFDC, and WASP) in order to compare the predicted response of chlorophyll-a concentrations at station BANT-3 in the tributary embayment to various scenarios of reducing point source total phosphorus effluent limits and also nonpoint source reductions in the watershed. Table 6.3.2.2 provides a description of each reduction scenario considered.

The first three rows provide the results of the calibrated model run, the natural condition model run, and the permit condition model run. The calibrated scenario model run is representative of the model response to existing conditions during the model simulation period of January 1, 2007 to December 31, 2012. The natural condition scenario run is representative of a hypothetical, completely natural watershed that has not been impacted by any anthropogenic sources. In order to simulate a natural condition in the watershed, all NPDES point sources were removed from the model and all existing land uses were converted to 100% forested. The results of the natural condition run serve as a “best case scenario” benchmark for the waterbody and also serve as a point of reference when assessing the cumulative impact of anthropogenic pollution in the waterbody.

The permit condition scenario is intended to be representative of “worst case” conditions in regards to how NPDES permitted discharges and also withdrawal sources in the watershed are simulated in the model network. In order to represent a worst case approach in the watershed, all the NPDES point sources in the Locust Fork watershed are simulated at their respective maximum allowable NPDES permit effluent limits and also at their maximum design effluent flowrate. For the industrial type NPDES point sources, the effluent flowrate in the permit condition scenario was based upon the long term average discharge flowrate, which is standard practice for developing effluent limitations for industrial facilities. For the municipal type NPDES point sources (i.e., POTWs), the effluent flowrate utilized in the permit condition scenario was based upon each facility's permitted design flow, per Departmental Regulations (335-6-6-.15(2)(a) Calculating NPDES Permit Limitations). Furthermore, all water withdrawal sources in the watershed (both public water supply withdrawal sources and industrial withdrawal sources) are simulated at their maximum withdrawal flow rate.

In the permit condition scenario, the effluent limitations for each point source are set at their maximum allowable permit limitations for the following pollutants, if applicable: $CBOD_5$, NH_3-N, TKN, DO, and Temperature. For those effluent parameters for which the Department does not require a specific numeric limit and requires only monitoring (in this case, nutrient parameters like total phosphorus), the effluent concentration utilized in the model is based upon a 90th percentile of the monitored values from DMRs submitted to the Department during 2006-2012. The existing land use cover, derived from the 2011 National Land Cover Database, was simulated in the model network for the permit condition run (i.e., no changes we made to the landuse cover during the permit condition scenario run and subsequent reduction scenarios).

In order to compare the predicted instream chlorophyll-a response to various approaches of reducing point source effluent limits for total phosphorus, a series of reduction scenarios were examined. Each reduction scenario included identifying a numeric total phosphorus effluent limitation for point sources in the Locust Fork watershed. All continuous point sources in the watershed were evaluated based upon their permitted effluent flowrate and resulting total phosphorus loading to the watershed and thus placed into one of the three following categories:

Table 6.3.2.1 Point Source Categories

Point Source Category	Effluent Flowrate (Qw)
Class 1	Qw ≥ 1.0 MGD
Class 2	Qw < 1.0 MGD & Qw ≥ 0.1 MGD
Class 3	Qw < 0.1 MGD

For each reduction scenario, a total phosphorus (TP) effluent limitation was specified for each point source type category as illustrated in the table above. Furthermore, the Department also adopted a 36% reduction to total phosphorus loading from MS4 sources and nonpoint sources in the TMDL reduction scenarios (see Table 6.3.2.2 Locust Fork TMDL Reduction Scenarios) based on an analysis of the relationship between stormwater driven total phosphorus load reductions in the watershed and the resulting instream chlorophyll-a concentrations. For further details, reference sections 7.4.2 and 7.5. See table 6.3.2.2 below for a list of each considered TMDL reduction scenario.

Table 6.3.2.2 Locust Fork and Village Creek TMDL Reduction Scenarios

Scenario Description	March - October Total Phosphorus Effluent Limit			Urban Nonpoint Source (MS4)	Nonpoint Source
	Class 1	Class 2	Class 3		
	Effluent Flowrate ≥ 1 MGD	1 MGD > Effluent Flowrate ≥ 0.1 MGD	Effluent Flowrate < 0.1 MGD	TP Load Percent Reduction	TP Load Percent Reduction
Calibrated Run	Existing (2006-2012)	Existing (2006-2012)	Existing (2006-2012)	N/A	N/A
Natural Condition	No Point Source Discharges	No Point Source Discharges	No Point Source Discharges	100% Forested Landuse	100% Forested Landuse
Permit Condition	DMR - TP @ 90th Percentile	DMR - TP @ 90th Percentile	DMR - TP @ 90th Percentile	N/A	N/A
Reduction Scenario #1	DMR - TP @ 90th Percentile	DMR - TP @ 90th Percentile	DMR - TP @ 90th Percentile	36%	36%
Scenario #2	2 mg/L	3 mg/L	3 mg/L	36%	36%
Scenario #3	2 mg/l	2 mg/l	2 mg/l	36%	36%
Scenario #4	1 mg/l	3 mg/L	3 mg/L	36%	36%
Scenario #5	1 mg/l	2 mg/l	2 mg/l	36%	36%
Scenario #6	1 mg/L	8.34 lbs/day	8.34 lbs/day	36%	36%
Scenario #7	0.5 mg/L	8.34 lbs/day	8.34 lbs/day	36%	36%
Scenario #8	0.3 mg/L	8.34 lbs/day	8.34 lbs/day	36%	36%
Scenario #9	0.2 mg/L	8.34 lbs/day	8.34 lbs/day	36%	36%
Scenario #10	0.15 mg/L	8.34 lbs/day	8.34 lbs/day	36%	36%
Scenario #11	0.10 mg/L	8.34 lbs/day	8.34 lbs/day	36%	36%
Scenario #12	0.3 mg/L	1 mg/l	5 mg/l	36%	36%
Scenario #13	0.2 mg/L	1 mg/l	8.34 ppd	36%	36%
Scenario #14	0.25 mg/L	2 mg/l	5 mg/l	36%	36%
Scenario #15	0.25 mg/L	2 mg/l	6 mg/l	0%	0%
Scenario #16	0.25 mg/L	2 mg/l	6 mg/l	36%	36%

6.3.3 TMDL Scenarios Results

The table below summarizes the results of the TMDL reduction scenarios. The chlorophyll-a values in the table below are representative of the calculated average chlorophyll-a concentration based upon the predicted WASP model output at station BANT-3 during the period of April 1st – October 31st for each year in the simulation. The Bankhead WASP model was set up to output the predicted chlorophyll-a concentrations for four times each day (12:00 AM, 6:00 AM, 12:00 PM, and 6:00 PM). This interval was selected in order to capture the natural variability of the chlorophyll-a concentrations observed within each given day, based upon fluctuations of ambient temperature and available sunlight.

Table 6.3.3.1 Locust Fork TMDL Reduction Scenario Results

ID	Description			Station	Chlorophyll-a µg/l - Growing Season Average (April 1st – October 31st)						Overall GS Average
					2007	2008	2009	2010	2011	2012	2007-2012
M	Measured			BANT-3	27.2 n=7[a]		24.6 n=7[a]		11.7 n=7[a]	15.1 n=7[a]	19.7
CAL	Calibrated			BANT-3	19.2	12.6	12.7	12.8	13.6	20.6	15.3
NC	Natural Conditions			BANT-3	1.1	1.8	2	1.5	1.5	2.4	1.7
PC	Permit Conditions			BANT-3	73.2	36.8	25.6	55.8	40.2	33.5	44.2
Run #1	LA Reduction Only			BANT-3	73.2	36.7	25.5	55.7	40.1	33.5	44.1
TMDL Run	**Class 1 Qw ≥ 1 mgd**	**Class 2 1 mgd > Qw ≥ 0.1 mgd**	**Class 3 Qw < 0.1 mgd**	**Station**	**Chlorophyll-a µg/l - Growing Season Average (April 1st – October 31st)**						**Overall GS Average**
					2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2007-2012**
Run #2	2 mg/L	3 mg/L	3 mg/L	BANT-3	77	40.1	26.2	62	42.8	34.9	47.2
Run #3	2 mg/l	2 mg/l	2 mg/l	BANT-3	76.8	39.9	26.2	61.6	42.6	34.8	47.0
Run #4	1 mg/l	3 mg/L	3 mg/L	BANT-3	59.1	28.3	20.8	40.6	30.4	28.4	34.6
Run #5	1 mg/l	2 mg/l	2 mg/l	BANT-3	58.6	28	20.6	40	30	28.2	34.2
Run #6	1 mg/L	8.34 lbs/day	8.34 lbs/day	BANT-3	61.1	29.5	21.6	42.7	31.9	29.2	36.0
Run #7	0.5 mg/L	8.34 lbs/day	8.34 lbs/day	BANT-3	46.1	21.2	16.5	28	22.8	24.4	26.5
Run #8	0.3 mg/L	8.34 lbs/day	8.34 lbs/day	BANT-3	38.4	17.3	13.7	21.5	18.4	21.4	21.8
Run #9	0.2 mg/L	8.34 lbs/day	8.34 lbs/day	BANT-3	34.1	15	11.9	18.1	15.9	19.6	19.1
Run #10	0.15 mg/L	8.34 lbs/day	8.34 lbs/day	BANT-3	31.8	13.8	11.0	16.3	14.5	18.6	17.7
Run #11	0.10 mg/L	8.34 lbs/day	8.34 lbs/day	BANT-3	29.4	12.5	10.0	14.6	13.2	17.4	16.2
Run #12	0.3 mg/L	1 mg/l	5 mg/l	BANT-3	33.8	14.6	11.4	17.5	15.0	18.9	18.5
Run #13	0.2 mg/L	1 mg/l	8.34 lbs/day	BANT-3	31.7	13.6	10.7	16.1	14.1	18.3	17.4
Run #14	0.25 mg/L	2 mg/l	5 mg/l	BANT-3	32.3	13.8	10.8	16.4	14.2	18.3	17.6
Run #15[b]	0.25 mg/L	2 mg/l	6 mg/l	BANT-3	32.6	14.1	11.1	16.8	14.6	18.6	18.0
Run #16	**0.25 mg/L**	**2 mg/l**	**6 mg/l**	**BANT-3**	**32.5**	**13.9**	**10.8**	**16.5**	**14.3**	**18.4**	**17.7**

a: n=Number of samples
b: Scenario run with 0% LA reduction

Multiple TMDL reduction scenarios were assessed in order to achieve an overall growing season average concentration less than the established chlorophyll-a target concentration of 18 µg/L. The Department considered adopting a load based effluent limitation of 8.34 lbs/day for Class 2 and 3 discharges (see Figure 6.3.3.1 Runs #6-11, 13). However, an evaluation of the historical DMRs for the Class 2 and 3 facilities indicated that for the majority of those facilities, a load based effluent limitation of 8.34 lbs/day would in fact result in an allowable total phosphorus load that was greater than the historical average total phosphorus load from those facilities. Consequently, since a greater percentage of the allowable total phosphorus contribution from point sources would be allocated to the Class 2 and 3 facilities, more stringent effluent limitations would be necessary for the Class 1 facilities in order to meet the proposed chlorophyll-a target of 18 µg/L. The Department thus decided that issuing a concentration based effluent limitation for all three categories of discharges would be a more reasonable and equitable approach.

The figure below illustrates the results of the TMDL reduction scenarios. The overall growing season average chlorophyll-a value represents the average chlorophyll-a concentration calculated from each yearly growing season average during the modeled simulation period, 2007 – 2012. The final applicable point source total phosphorus effluent limitations in the TMDL will be based upon those March - October effluent limits considered in TMDL scenario Run #16 (i.e., Class 1 TP: 0.25 mg/l, Class 2 TP: 2 mg/l, & Class 3 TP: 6 mg/l).

Figure 6.3.3.1 Point Source Load Contribution

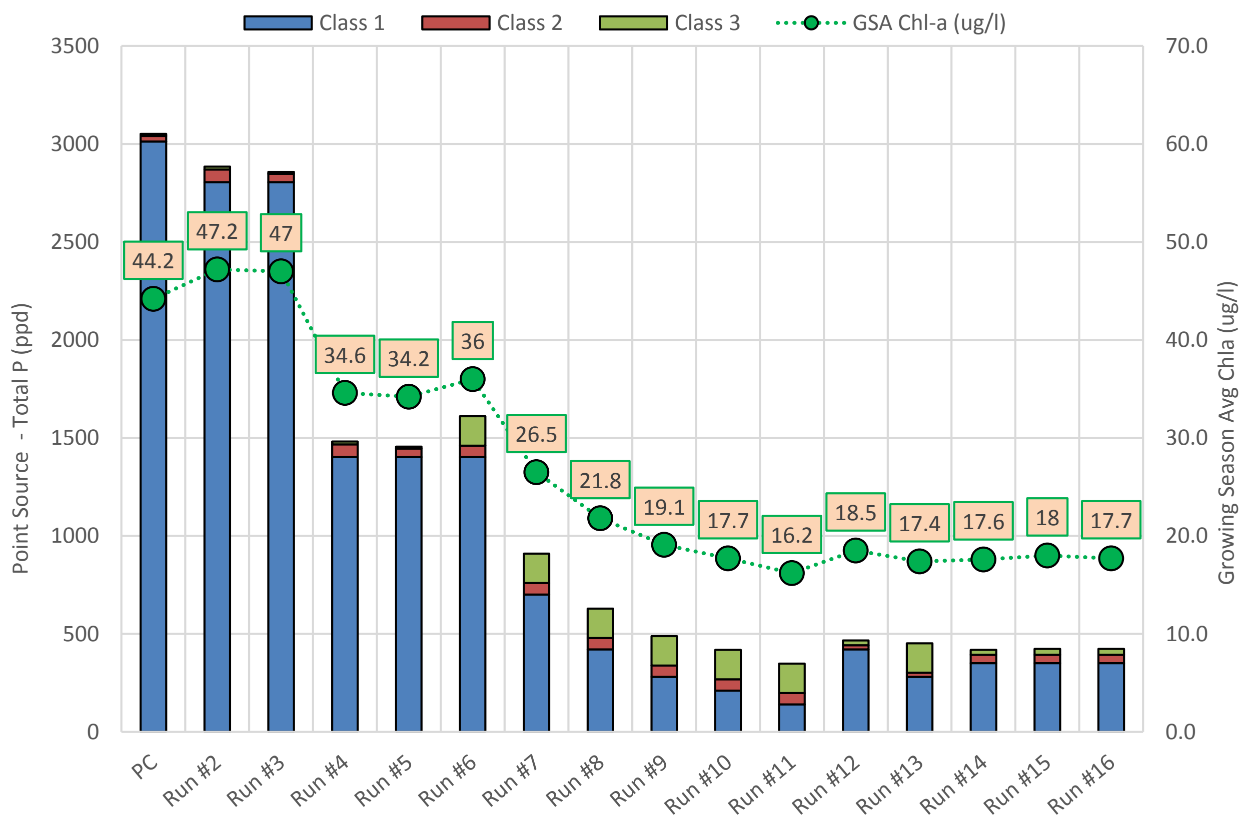
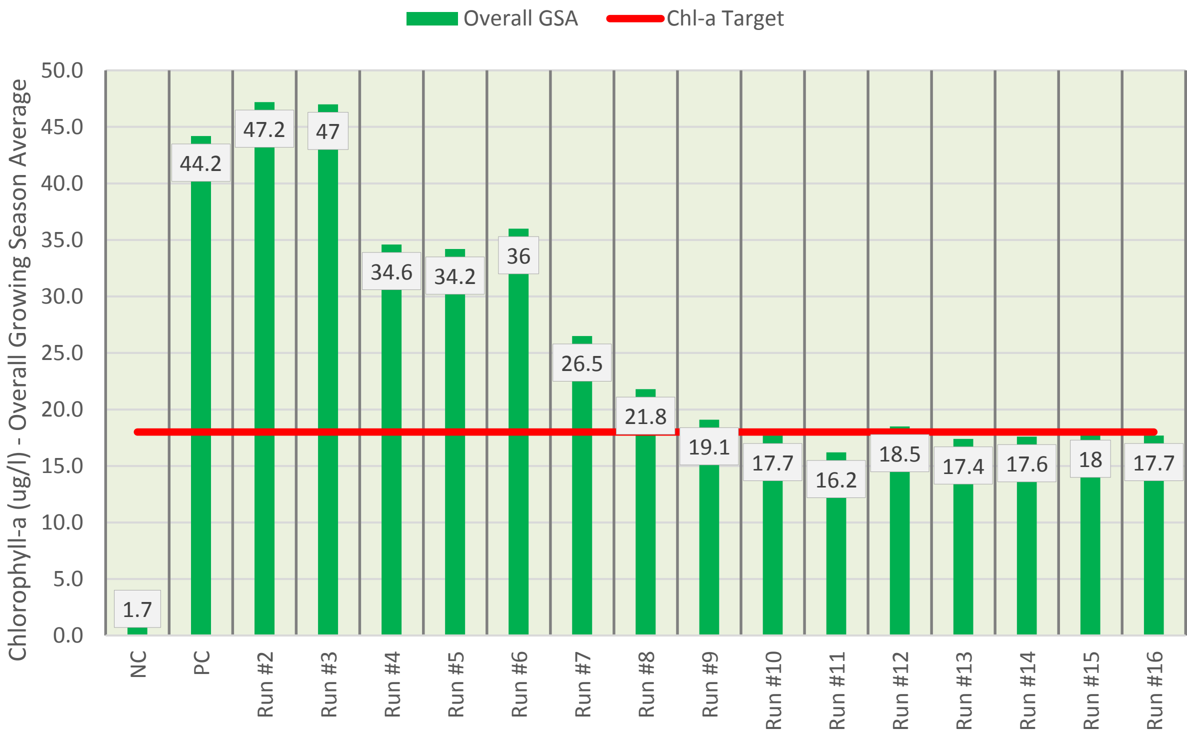


Figure 6.3.3.2 Locust Fork TMDL Scenario Chlorophyll-a Results



Chapter 7 Expression and Allocation of the TMDL

7.1 Components of the TMDL

A TMDL represents the total amount of a pollutant load that can be assimilated by the receiving water while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are comprised of the sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

In order to develop the TMDL, the following components were considered:

- Numeric Targets
- Existing/Baseline Conditions
- Critical Conditions
- Waste Load Allocations
- Load Allocations
- Margin of Safety (MOS)
- Seasonal Variation

Based on the best available science pertinent to the protection of designated uses, extensive assessment of all available data for the Locust Fork, and a detailed modeling analysis, significant reductions in the total phosphorus loading to the Locust Fork will be necessary to meet the numeric target established in the nutrient impaired segment of the tributary embayment.

7.2 Numeric Targets

The TMDL endpoint ultimately represents the instream water quality target that is used to quantify the necessary total phosphorus load reductions in order to maintain water quality standards. In this application, the TMDL endpoint used to address the nutrient impairments in the Locust Fork is a growing season (April – October) average chlorophyll-a concentration of 18 μg/L at ADEM reservoir station BANT-3.

7.3 Existing/Baseline Conditions

The existing conditions in the model network are based on the following conditions in the Locust Fork watershed during the simulation period from January 1, 2007 to December 31, 2012: NPDES point source discharge effluent flowrate and pollutant concentrations are derived from each facility's submitted monthly Discharge Monitoring Reports (DMRs) during the simulation period and the existing nonpoint source loading in the watershed is based upon the 2011 National Land Cover Database (NCLD 2011). The existing conditions for the Locust Fork are considered to be the results of the calibrated model network (LSPC, EFDC, and WASP) during the simulation period.

7.3 Critical Conditions

The network of dynamic water quality models utilized in the Locust Fork nutrient TMDL were calibrated by comparing each model's predicted output to actual measured instream water quality data collected by the Department during the model simulation period of January 1, 2007 through December 31, 2012. However, in order to ensure the TMDL is protective of water quality during a "worst case scenario," an assessment of the chlorophyll-a response in the Locust Fork tributary embayment must be made during a defined subset of the simulation period when conditions are the most critical in regards to promoting the excessive growth of algal biomass. Critical conditions in a reservoir are typically exhibited during periods of high temperatures and low precipitation amounts in the watershed which can lead to elevated instream temperatures, increased residence time, decreased re-aeration, and also slower ambient river velocities. All of these factors directly translate to increased algal production in a reservoir.

EPA's *Nutrient Criteria Technical Guidance Manual: Rivers and Streams* (EPA, 2000) states that "Nutrient and algal problems are frequently seasonal in streams and rivers, so sampling periods can be targeted to the seasonal periods associated with nuisance problems." A review of ambient water quality data collected in the Locust Fork tributary embayment suggests the critical time period associated with nutrient over-enrichment that results in excessive algal growth in the Locust Fork embayment is during the growing season months of April through October.

Therefore, in order to assess the Locust Fork tributary embayment during critical conditions, the resulting overall chlorophyll-a average concentration defined for each year in the model simulation period will be based upon an assessment of chlorophyll-a output during the growing season from April 1st through October 31st.

7.4 Waste Load Allocations

7.4.1 WLA – NPDES Wastewater Discharges

The required total phosphorus effluent limitations for Class 1, Class 2, and Class 3 NPDES regulated point sources are given in the table below, based upon the results from TMDL run #16. The applicable total phosphorus effluent limitations for NPDES-permitted point sources should be incorporated into NPDES permits as a monthly average total phosphorus (TP) limit during the months of March - October.

Table 7.4.1.1 Class 1 NPDES Facilities (Effluent Flowrate ≥ 1.0 MGD)

NPDES #	Facility	Type	Receiving Waterbody	County	Effluent Flowrate[a] (MGD)	TP Monthly Average (mg/l)
AL0023647	Jefferson County Village Creek WWTP - 11	Municipal	Village Creek	Jefferson	60.0	0.25
AL0023647	Jefferson County Village Creek WWTP - 21	Municipal	Village Creek	Jefferson	60.0	0.25
AL0026913	Jefferson County Fivemile Creek WWTP	Municipal	Fivemile Creek	Jefferson	30.0	0.25
AL0049603	Boaz Slab Creek WWTP	Municipal	Slab Creek UT	Marshall	4.88	0.25
AL0003247	ERP Compliant Coke LLC Inc.	Industrial	Fivemile Creek	Jefferson	4.73	0.25
AL0022926	Jefferson County Turkey Creek WWTP	Municipal	Turkey Creek	Jefferson	5.00	0.25
AL0049549	Oneonta WWTP	Municipal	Mill Creek	Blount	2.20	0.25
AL0001449	Tyson Foods Blountsville	Industrial	Graves Creek	Blount	1.339	0.25

a. Design Flowrate was used for Municipal Type Discharges. Long Term Average Flowrate was used for Industrial Type Discharges

Table 7.4.1.2 Class 2 NPDES Facilities (Effluent Flowrate < 1.0 MGD and Effluent Flowrate ≥ 0.10 MGD)

NPDES #	Facility	Type	Receiving Waterbody	County	Effluent Flowrate[a] (MGD)	TP Monthly Average (mg/l)
AL0056120	Jefferson County Prudes Creek WWTP	Municipal	Fivemile Creek	Jefferson	0.90	2
AL0053121	Morris Manor Apartments WWTP	Municipal	Turkey Creek	Jefferson	0.50	2
AL0003417	ABC Coke, Drummond Company Inc.	Industrial	Fivemile Creek	Jefferson	0.404	2
AL0001554	CMC Steel Alabama	Industrial	Village Creek UT	Jefferson	0.380	2
AL0058572	Snead WWTP	Municipal	Locust Fork	Blount	0.15	2
AL0073261	Cleveland WWTP	Municipal	Dry Creek UT	Blount	0.15	2
AL0050881	Warrior WWTP	Municipal	Cane Creek	Jefferson	0.10	2

a. *Design Flowrate was used for Municipal Type Discharges. Long Term Average Flowrate was used for Industrial Type Discharges*

Table 7.4.1.3 Class 3 NPDES Facilities (Effluent Flowrate < 0.10 MGD)

NPDES #	Facility	Type	Receiving Waterbody	County	Effluent Flowrate[a] (MGD)	TP Monthly Average (mg/L)
AL0071170	County Line Industrial Park WWTP	Municipal	Longs Branch	Blount	0.099	6
AL0051055	Peachtree Crossing Mobile Home Park	Municipal	Black Creek UT	Jefferson	0.09	6
AL0076261	West Blount Lagoon	Municipal	Hogeland Creek	Jefferson	0.09	6
AL0021237	Altoona Lagoon	Municipal	Locust Fork	Etowah	0.07	6
AL0027642	Forestdale MHP	Municipal	Fivemile Creek	Jefferson	0.03	6
AL0050563	Susan Moore High School	Municipal	Locust Fork UT	Blount	0.03	6
AL0056553	The Cove Mobile Home Park	Municipal	Turkey Creek	Jefferson	0.024	6
AL0054348	Locust Fork High School Lagoon	Municipal	Blackburn Fork	Blount	0.022	6
AL0062251	Brookside Village WWTP	Municipal	Newfound Creek	Jefferson	0.022	6
AL0032301	Dixie-Manor Housing Project	Municipal	Self Creek UT	Jefferson	0.02	6
AL0071170	County Line Industrial Park WWTP	Municipal	Longs Branch	Blount	0.02	6
AL0051161	Bottenfield Junior High School	Municipal	Prudes Creek UT	Jefferson	0.017	6
AL0047546	Bradford Parkside Health Services WWTP	Municipal	Thomas Creek	Jefferson	0.015	6
AL0054011	River Bend Townhouses WWTP	Municipal	Turkey Creek	Jefferson	0.015	6
AL0075256	North Jefferson Middle School WWTP	Municipal	Lick Creek	Jefferson	0.012	6
AL0051195	Johnson Elementary School Lagoon	Municipal	Self Creek UT	Jefferson	0.01	6
AL0068675	Southeastern Elementary School	Municipal	Campbell Creek	Blount	0.005	6
AL0057827	Sharon Heights MHP	Municipal	Fivemile Creek	Jefferson	0.003	6

a. *Design Flowrate was used for Municipal Type Discharges. Long Term Average Flowrate was used for Industrial Type Discharges*

7.4.2 WLA – NPDES Stormwater Discharges

Urban areas with the designation of Municipal Separate Storm Sewer System (MS4) fall under the regulation of the NPDES program and therefore are considered to be point sources by the EPA. However, stormwater discharges are similar to nonpoint sources in a watershed in that pollutant loads originate from diffuse sources and the magnitude of pollutant loading to the waterbody depends heavily upon the frequency, duration, and intensity of rainfall events in the watershed. Furthermore, the intention of stormwater NPDES permits are to implement controls, or BMPs, in the watershed to effectively reduce the exposure of stormwater to pollutants rather than attempting to address and treat the stormwater discharge from each individual outfall.

Currently, stormwater NPDES permits do not include numeric total phosphorus limitations. Therefore, compliance with this TMDL will be demonstrated through the implementation of stormwater management plans (SWMPs). The SWMPs will address nutrient reductions in the watershed by implementing appropriate BMPs, eliminating illicit discharges, conducting instream water quality monitoring, and education and outreach. For the purposes of this TMDL, the 36% reduction to existing MS4 total phosphorus loads should not be interpreted as a numeric permit limitation.

7.5 Load Allocations

As previously mentioned in Section 4.3, Department-collected water quality data on the Locust Fork and its tributaries suggests the nutrient loading to those waterbodies from nonpoint sources in the watershed is minimal. Nevertheless, a percent reduction to the existing total phosphorus load, reflected in the load allocation component described below, was analyzed in the TMDL reduction scenarios in an effort to make fair and equitable allocations to all stakeholders in the watershed and to reduce nutrient loading for the Locust Fork watershed as a whole. In addition to achieving the goals of the Locust Fork and Village Creek Nutrient TMDL, nutrient reductions to nonpoint sources will also serve to reduce the impact of nutrient enrichment through the implementation of BMPs at a more localized level to further improve water quality within those specific tributaries. The Department recognizes that any total phosphorus load reductions to nonpoint sources in the watershed will be implemented by means of voluntary, incentive-based mechanisms, outside of the permitting programs.

In the Locust Fork watershed, the primary landuse types that may be addressed through the implementation of BMPs in an effort to reduce the nonpoint source nutrient loading to the waterbody include developed (open space, low intensity, medium intensity, and high intensity), barren, herbaceous, hay/pasture, and cultivated crops. Forested, shrub, and wetland landuse types are considered representative of natural conditions, and therefore do not typically contribute excessive nonpoint source driven nutrient loadings to the Locust Fork. Refer to Figure 4.3.1 and Table 4.3.1 for a detailed description of the landuse types found in the Locust Fork watershed.

The load allocation component for the Locust Fork and Village Creek Nutrient TMDL was derived from an evaluation of the LSPC watershed model output for the Locust Fork segment located in the headwaters of the watershed, illustrated by LSPC sub-watershed 461 shown in Figure 7.5.1.2. An evaluation of the total phosphorus load from sub-watershed 461 was chosen as representative of the existing nonpoint source total phosphorus loading to the Locust Fork waterbody based upon consideration of the following factors:

- The drainage watershed for the Locust Fork at this reach location does not contain any continuous point source discharges. Therefore, the origin of the nutrient loading to the waterbody is presumably attributable to nonpoint sources in the watershed.
- The landuse for the drainage area of sub-watershed 461 is comprised heavily of agriculture and includes an urban component as well. Both agricultural practices in a watershed and stormwater runoff associated with urban development can account for a significant source of nonpoint source pollution to nearby rivers and streams.

The allowable load allocation for the Locust Fork was calculated based on an analysis of the LSPC watershed model under "natural conditions" [i.e., converted all anthropogenic landuses in the watershed to a natural condition (forest land cover)]. This analysis provides an estimation of the magnitude of the human induced loads to the Locust Fork waterbody based upon changes to the landuse type from a forested cover that delivers minimal nutrient loading to the waterbody compared to the existing landuse cover types that are more susceptible to nonpoint source pollution, like cultivated crops and pasture. The figure below illustrates the results of the predicted LSPC daily total phosphorus load for the existing landuse cover and the natural conditions landuse cover type for the Locust Fork waterbody represented at sub-watershed 461.

Figure 7.5.1.1 Locust Fork Sub-watershed 461: Daily TP Load

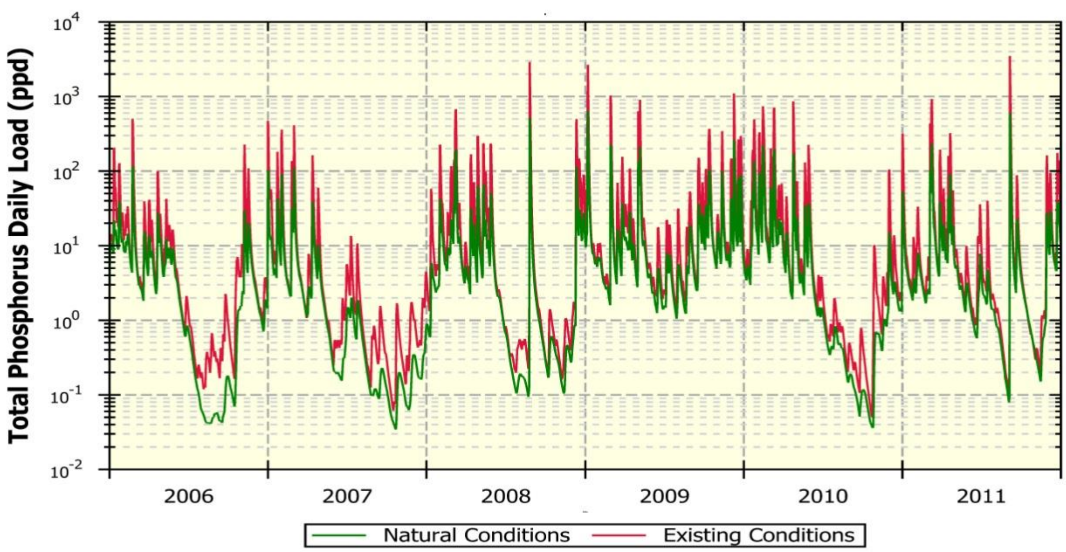


Figure 7.5.1.2 Locust Fork Sub-watershed 461: 2011 NLCD

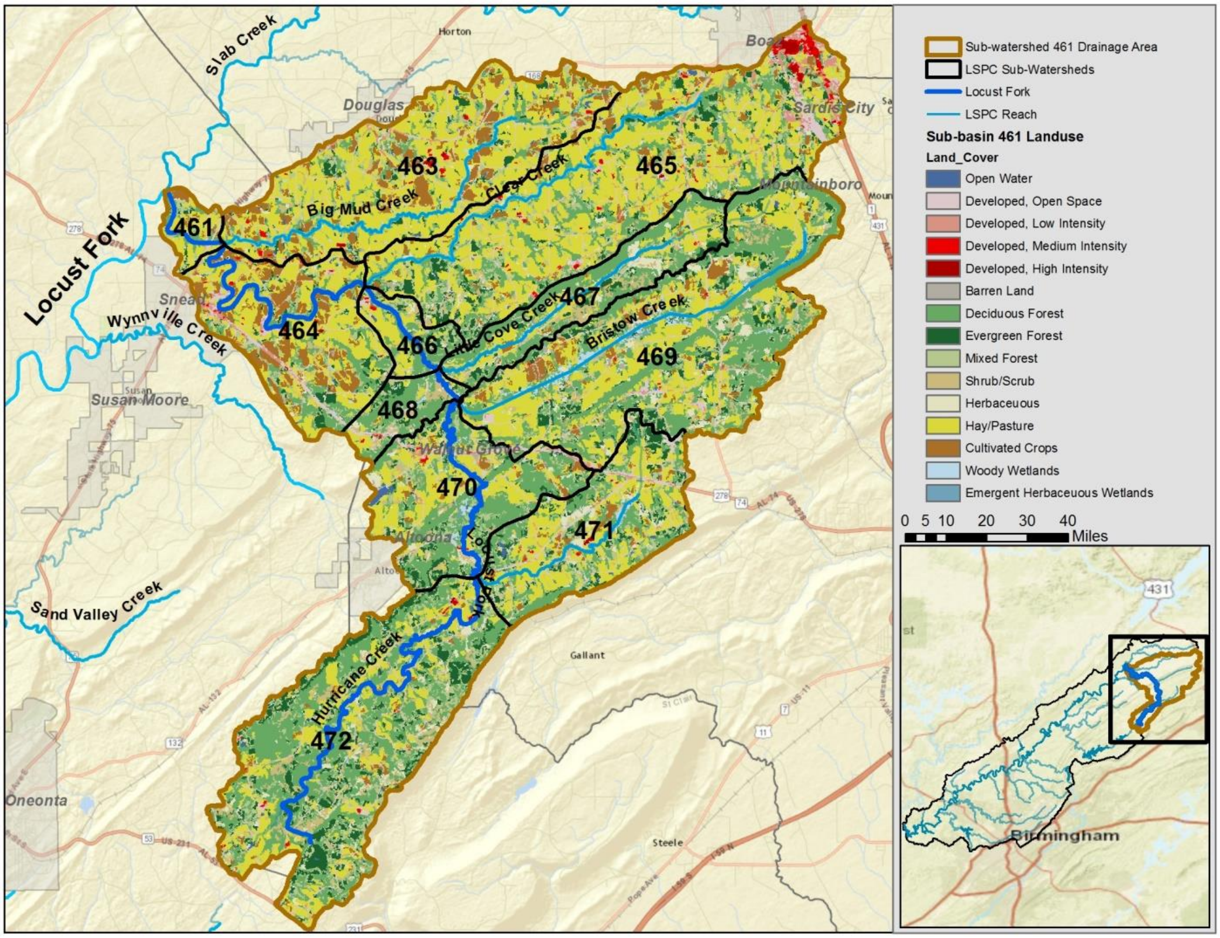


Table 7.5.1.1 Locust Fork Sub-watershed 461: 2011 NLCD

Land Use Description	Acres	Square Miles	%
Open Water	422.55	0.66	0.45
Developed, Open Space	4700.32	7.34	4.99
Developed, Low Intensity	1404.20	2.19	1.49
Developed, Medium Intensity	533.75	0.83	0.57
Developed, High Intensity	201.71	0.32	0.21
Barren Land	134.77	0.21	0.14
Deciduous Forest	25395.93	39.68	26.95
Evergreen Forest	6892.24	10.77	7.32
Mixed Forest	8773.92	13.71	9.31
Shrub/Scrub	4504.83	7.04	4.78
Grassland/Herbaceous	2438.78	3.81	2.59
Pasture/Hay	31729.29	49.58	33.68
Cultivated Crops	6090.95	9.52	6.46
Woody Wetlands	908.04	1.42	0.96
Emergent Herbaceous Wetlands	85.40	0.13	0.09
Sum	***94216.69***	***147.21***	***100.00***

Land Use Description	Acres	Square Miles	Percent (%)
Developed	6839.98	10.69	7.26
Forested/Wetlands	42055.53	65.71	44.64
Agriculture	37820.24	59.09	40.14
Grassland/Shrubs	6943.61	10.85	7.37
Barren Land	134.77	0.21	0.14
Open Water	422.55	0.66	0.45
Sum	***94216.69***	***147.21***	***100.00***

The load allocation percent reduction implemented in the TMDL was based upon an evaluation of the median daily TP load under the existing conditions compared to the median daily TP load under natural conditions, illustrated in the table below:

Table 7.5.1.2 Load Allocation Calculations for Locust Fork Sub-watershed 461

	Existing Conditions	**Natural Conditions**
Statistic	**TP Daily Load (ppd)**	**TP Daily Load (ppd)**
Minimum	0.05	0.03
10th percentile	0.36	0.15
Median	**3.85**	**2.46**
90th Percentile	58.00	20.18
Maximum	3499.31	637.54
Average	33.03	10.22
	Percent Reduction[a]	**36%**

a. Based on Median Load

In order to explore the sensitivity of the model network to the load allocation component of the TMDL, a globalized 36% reduction was implemented to the total phosphorus loads originating from those landuse types in the watershed associated with nonpoint source pollution identified earlier. The resulting predicted chlorophyll-a concentrations based upon Reduction Scenario #1 (i.e., Permit Conditions for Point Sources, with 36% LA reduction in the watershed) indicate that when solely addressing the nonpoint source nutrient loading in the watershed, the resulting impact on instream chlorophyll-a concentrations is minimal (see Table 6.3.3.1 Locust Fork Reduction Scenario Results). However, a percent reduction to the existing total phosphorus load from nonpoint sources is included in the TMDL to make fair and equitable allocations to all stakeholders in the watershed and to reduce nutrient loading for the Locust Fork watershed as a whole.

7.6 Margin of Safety

There are two methods for incorporating a margin of safety (MOS) in the analysis: a) by implicitly incorporating the MOS using conservative model assumptions to develop allocations; or b) by explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations. An implicit MOS was incorporated in the Locust Fork TMDL due to the fact that the TMDL was developed based upon a modeling approach that utilized several conservative (i.e., worst case) conditions. The conservative model conditions used in the model network include the following:

- For the permit condition model run, all continuous NPDES point sources in the Locust Fork watershed were set at their respective permit effluent limitations and also at their design effluent flowrate (for municipal sources).
- For the permit condition model run, surface water withdrawal sources (both drinking water and also industrial sources) were set at design/plant capacity water withdrawal rates.

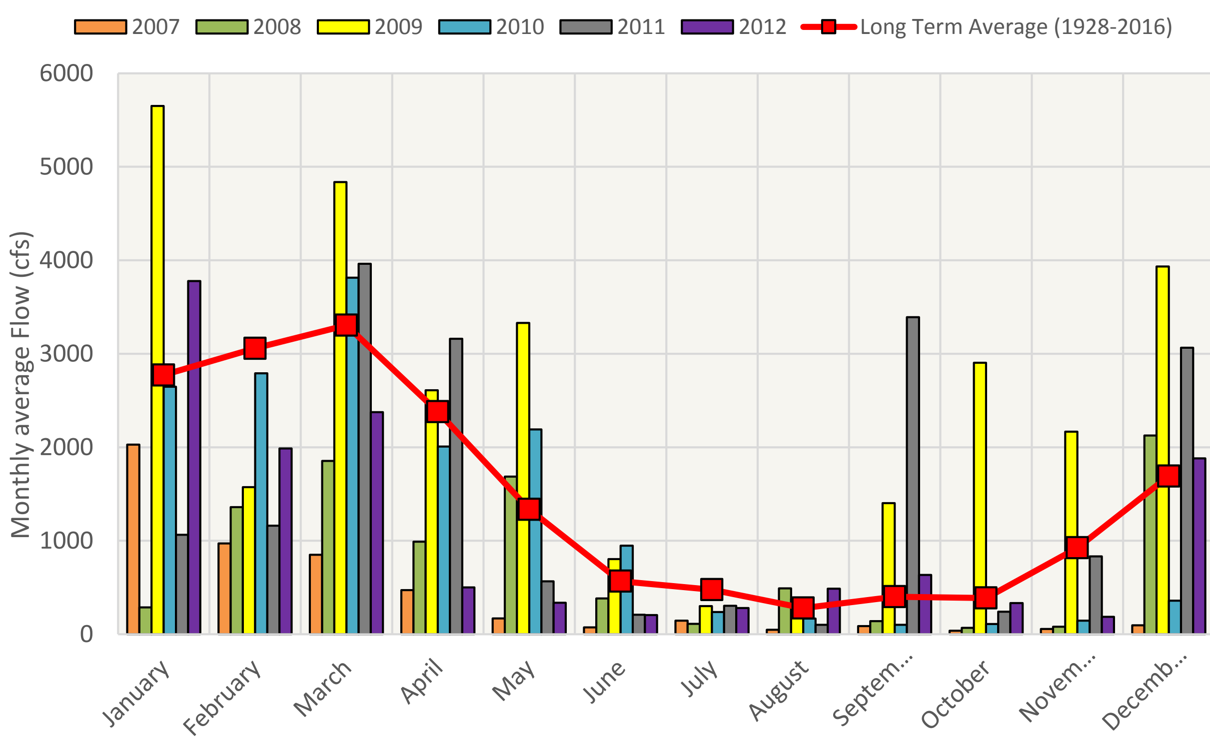
- All the sub-watershed land area modeled in the LSPC model is directly connected to streams.

7.7 Seasonal Variation

When assessing chlorophyll-a concentrations in a reservoir, the variability occurring within the algal growing season must be taken into account. The cooler months are generally less productive resulting in lower chlorophyll-a values while the warmer months are generally more productive with higher values typically recorded. Therefore, a TMDL should be protective of water quality over a range of possible conditions that are expected to occur within an impaired segment.

Seasonal variation is considered in the development of the TMDL by evaluating the model simulation period from January 1, 2007 to December 31, 2012, which included a range of hydrologic, meteorological and loading conditions observed in the Locust Fork watershed. The simulation period included 2007, a low flow year brought on during drought conditions, and also 2009 and 2010, considered relatively wet years. The figure below for USGS gage 02456500 Locust Fork at Sayre illustrates the monthly average flow for each simulation year, 2007 to 2012, compared to the long term average monthly flow, calculated from the entire period of record (1928-2016). The graph clearly illustrates the 2007 drought year that was characterized by extended periods of below average stream flow; similarly, the graph also illustrates the "wetter" years that were characterized with above average streamflow, like 2009 for instance.

Figure 7.7.1 Monthly Flow Analysis at USGS 02456500 Locust Fork at Sayre



Chapter 8 Locust Fork Nutrient TMDL

The final TMDL is based upon the necessary waste load allocation (WLA), load allocation (LA), and margin of safety (MOS) required to meet the numeric chlorophyll-a growing season average target of 18 µg/l, established at the compliance point located at the Locust Fork tributary embayment station BANT-3. For the purpose of this TMDL, the "Growing Season" is defined as the time period consisting of the months of April – October. However, an evaluation of the WASP model output suggests it is necessary to implement the NPDES point source total phosphorus effluent limitations during the period of March – October. Enforcing the necessary effluent limitations for point sources beginning a month prior to the growing season period will help to assure the instream chlorophyll-a target will be met during the growing season regardless of the following factors: relative location of the point source discharge within the watershed (i.e., direct discharge to Locust Fork or indirect discharge), time of travel for the Locust Fork wadeable segments in the headwaters of the watershed, and finally the hydraulic residence time in the tributary embayment segments further downstream.

The waste load allocation component for all of the continuous point sources in the Locust Fork watershed shall be applied as an effluent monthly average total phosphorus concentration limit applicable during the months of March – October.

Table 8.1.1 Locust Fork and Village Creek Nutrient TMDL

WLA (Continuous Sources)			WLA (MS4 Stormwater Sources)	LA (Stormwater Sources)	Margin of Safety
TP Effluent Limit for Class 1 (Qw ≥ 1 MGD)	TP Effluent Limit for Class 2 (Qw < 1 MGD & Qw ≥ 0.1 MGD)	TP Effluent Limit for Class 3 (Qw < 0.1 MGD)	Percent Reduction to existing TP Load	Percent Reduction to existing TP Load	
0.25 mg/L	2 mg/L	6 mg/L	36% [a]	36%	Implicit

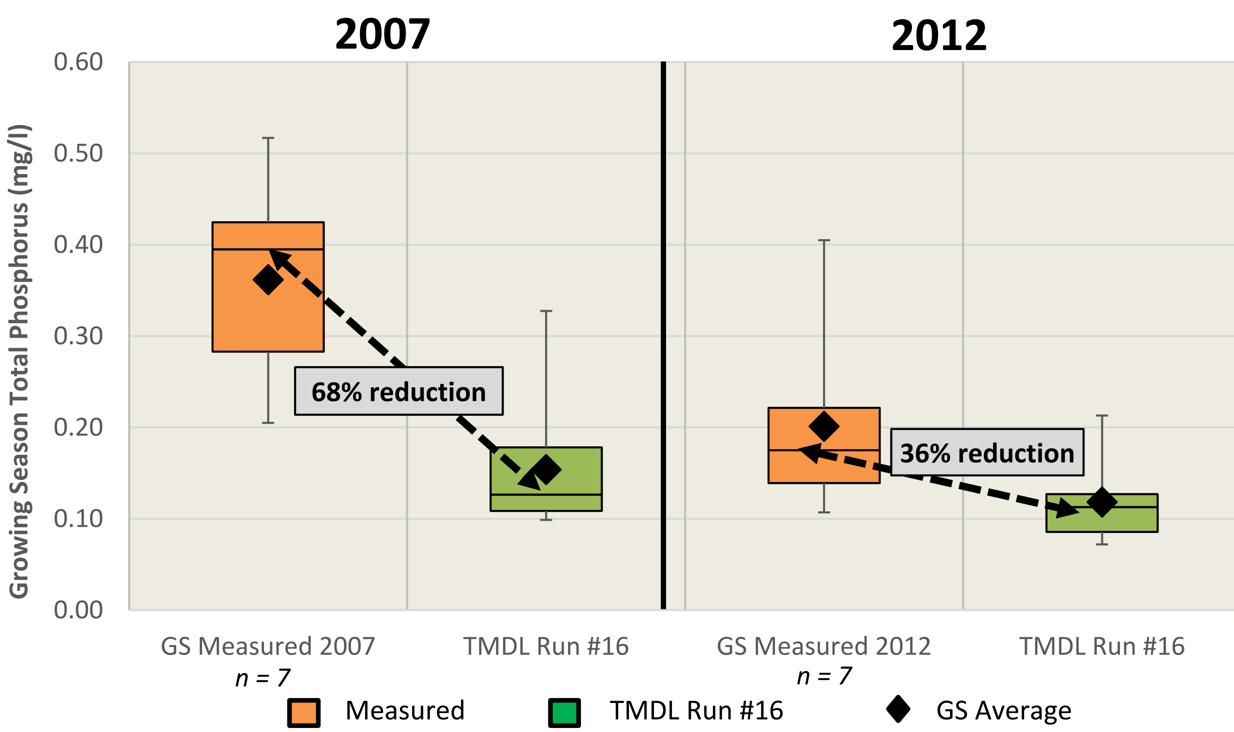
a. MS4 permits that are located in the Locust Fork Watershed must comply with this TMDL. MS4 permits are BMP-based and currently do not specify numeric total phosphorus limits. Therefore, TMDL compliance will be demonstrated through implementation and maintenance of BMPs on a case-by-case basis. For the purposes of this TMDL, the 36% reduction to MS4 Stormwater source total phosphorus loads should not be interpreted as a numeric permit limitation.

Chapter 9 Village Creek Nutrient TMDL

In addition to addressing the nutrient impairment on the mainstem of the Locust Fork, total phosphorus effluent limitations specified in the table above are also expected to reduce instream total phosphorus concentrations in several of the effluent dominated tributaries to the Locust Fork. Specifically, total phosphorus concentrations in the lower segment of Village Creek, which is also listed on the current 2016 §303(d) list as impaired by nutrients, are expected to decrease significantly as a result of reduced nutrient loading from point sources further upstream in the watershed.

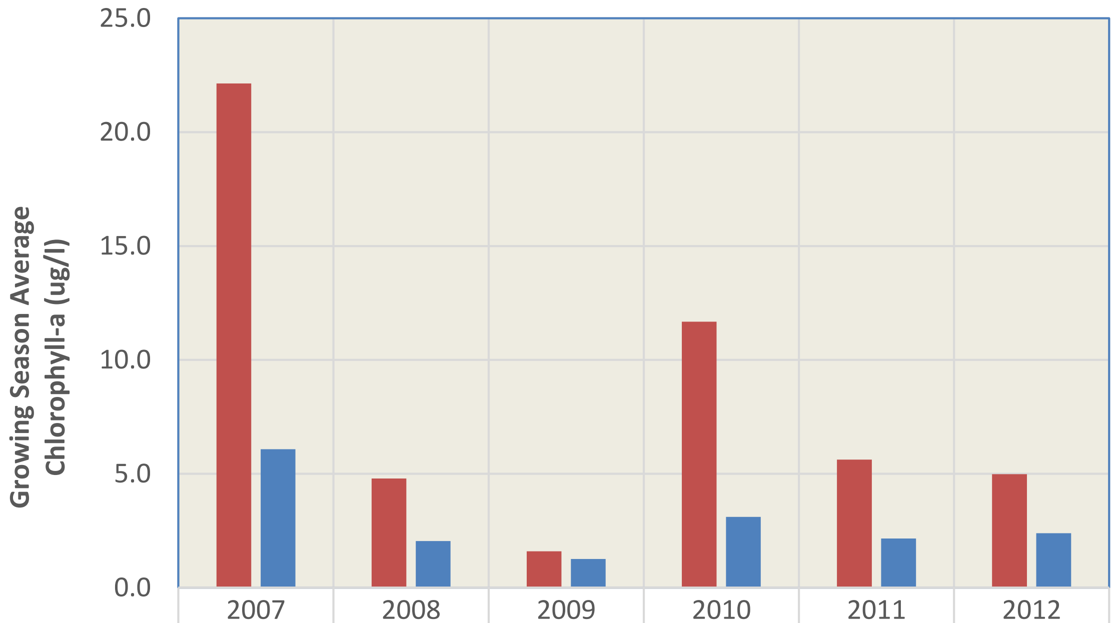
The existing nutrient impairment for Village Creek was based upon Department-collected water quality data from the existing wadeable station VLGJ-5. The figure below depicts a comparison of the measured total phosphorus concentrations at Village Creek station VLGJ-5 versus the model predictions at that site based on the final TMDL scenario (Run #16) during the 2007 and 2012 growing season time period (April-October). The graph illustrates a 68 percent reduction to instream total phosphorus concentrations as a result of the final TMDL effluent limitations during 2007, and a 36 percent reduction to total phosphorus concentrations in 2012.

Figure 9.1.1 Village Creek (VLGJ-5) TP Measured vs. TMDL Run #16



In addition to sampling the wadeable segments of Village Creek, the Department has also routinely collected water quality data from a tributary embayment station (BANT-8) in Village Creek as part of the RRMP (Rivers and Reservoirs Monitoring Program). An analysis of the predicted chlorophyll-a concentrations based upon the final TMDL scenario (Run #16) at the tributary embayment station BANT-8 indicate the TMDL effluent limitations are considered protective of water quality conditions in the Village Creek tributary embayment. The figure below depicts the predicted growing season average chlorophyll-a concentrations at station BANT-8 based on the final TMDL model run #16.

Figure 9.1.2 BANT-8 GSA Chlorophyll-a (µg/l) - Permit Condition vs TMDL Run #16



	2007	2008	2009	2010	2011	2012
Permit Condition	22.14	4.80	1.60	11.68	5.63	4.98
TMDL Run #15	6.08	2.05	1.26	3.11	2.16	2.39

In summary, an analysis of predicted instream total phosphorus concentrations at station VLGJ-5 and predicted chlorophyll-a concentrations at non-wadeable tributary embayment station BANT-8 in Village Creek indicate the reductions required to attain the aforementioned chlorophyll-a target of 18 µg/l in the Locust Fork tributary embayment at station BANT-3 will be protective of water quality in both the nutrient impaired mainstem Locust Fork segments and also the nutrient impaired downstream segment of Village Creek.

Chapter 10 TMDL Implementation

10.1 Implementation of Point Source Reductions

10.1.1 TMDL Implementation for Continuous Point Source Permits

Implementation of phosphorus reductions necessary to meet the growing season instream chlorophyll-a target concentration of 18 µg/l at compliance station BANT-3 will be achieved through the issuance of NPDES permits that will require effluent total phosphorus limits applicable during the months of March - October. The Department's NPDES Municipal and Industrial permitting program will be responsible for issuing the NPDES permits requiring the aforementioned total phosphorus concentration based effluent limitations. Furthermore, the implementation schedule for all municipal and industrial permittees will be determined on a case by case basis by ADEM's NPDES permitting program. The Department recognizes that the necessary effluent treatment process alterations and improvements will vary based on existing processes and already planned upgrades. Future requests for new or expanded NPDES permits which will discharge within the Locust Fork watershed will be evaluated on a case-by-case basis consistent the Department's permitting strategy for impaired waters.

10.1.2 TMDL Implementation for MS4 Permits

Urban areas with the designation of Municipal Separate Storm Sewer System (MS4) fall under the regulation of the Department's Stormwater Management NPDES permitting program. Each permittee in the Locust Fork watershed covered under an MS4 permit will demonstrate compliance with this TMDL through the implementation of stormwater management plans (SWMPs). The SWMPs will address nutrient reductions in the watershed by implementing appropriate BMPs, eliminating illicit discharges, conducting instream water quality monitoring, and education and outreach.

10.2 Implementation of Nonpoint Source Reductions

Voluntary, incentive-based mechanisms will be used to implement nonpoint source management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the Locust Fork. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. Therefore, TMDL implementation activities for nonpoint sources will be coordinated through interaction with local entities in conjunction with the Department's 319 Nonpoint Source Program.

10.3 Adaptive Management

The objective of the TMDL is to address the nutrient impaired reaches of the mainstem Locust Fork and Village Creek by implementing nutrient reductions to sources in the watershed that are contributing to the impairment. Reducing nutrient loading from point sources located on other major tributaries to the Locust Fork is expected to coincidentally improve the water quality conditions found in those tributaries. Nevertheless, the intent of the TMDL is to be protective of water quality on those impaired reaches of the Locust Fork and Village Creek explicitly identified in this document.

It is possible during the implementation of this TMDL that further evaluation of instream conditions within the Locust Fork and Village Creek, including biological and chemical monitoring, will reveal trends of improvement in both water quality and biological conditions. If so, any required implementation in the future may be revised according to the best available science at that time. Adaptive management, in conjunction with the implementation schedules as determined by ADEM's NPDES Municipal and Industrial permitting program, will allow the TMDL target to be validated or adjusted as necessary based on additional data that becomes available in the future.

Chapter 11 Follow Up Monitoring

ADEM has adopted a statewide approach to water quality management. Each year, ADEM's water quality resources are divided among multiple priorities statewide including §303(d) listed waterbodies, waterbodies with active TMDLs, and other waterbodies as determined by the Department. Monitoring will help further characterize water quality conditions resulting from the implementation of best management practices and load reductions in the watershed.

Chapter 12 Public Participation

As part of the public participation process, this TMDL document will be placed on public notice and made available for review and comment. A public notice will be prepared and published in the major daily newspapers in Montgomery, Huntsville, Birmingham, and Mobile, as well as submitted to persons who have requested to be on ADEM's postal and electronic mailing distributions. In addition, the public notice and subject TMDL will be made available on ADEM's Website: www.adem.state.al.us. The public can also request hard or electronic copies of the TMDL by contacting Ms. Kimberly Minton at 334-271-7826 or kminton@adem.alabama.gov. The public will be given an opportunity to review the TMDL and submit comments to the Department in writing. At the end of the comment period, all written comments received during the public notice period will become part of the administrative record. ADEM will consider all comments received by the public prior to final completion of this TMDL and subsequent submission to EPA Region 4 for final approval.

Chapter 13 References

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Appendix A

Locust Fork and Village Creek Water Quality Data (2005-2012)

STATION	VISIT_DATE	Flow cfs	Temp, Water c	Dissolved Oxygen mg/l	pH su	Turbidity ntu	Hardness mg/l	Conductivity Âµmhos/cm	Solids,Total Dissolved mg/l	DET_COND - Solids, Total Dissolved mg/l	Solids, Total Suspended mg/l	DET_COND - Solids, Total Suspended mg/l
LFKB-15	4/12/2012 11:41	32.1	13.3	8.5	7.2	9.7		151.4	104		5	
LFKB-15	5/2/2012 14:34	8.5	21.1	6.3	7.6	9.1		186.3				
LFKB-15	5/3/2012 11:50	16.1	19.7	5.9	7	6		189.2	88	JQ6	1	< MDL 1
LFKB-15	6/7/2012 11:21	13.5	19.8	6.7	6.9	13.5		164.6	92		1	< MDL 1
LFKB-15	7/19/2012 11:31	15.2	23.2	5.6	6.8	10		176	122		11	
LFKB-15	8/14/2012 17:15	14	23.1	6.4	6.8	141		162.7	196		20	JQ6
LFKB-15	9/12/2012 16:47	6.8	20.3	6.3	7.5	14.5		202.2	118		1	< MDL 1
LFKB-15	10/10/2012 16:54	14.2	15.4	8	7.4	12		153.9	80		9	
LFKB-15	11/14/2012 14:44	28.3	10.1	8	6.9	6.6		143.6	128		1	< MDL 1
LFKB-1	4/22/2008 11:40	222	18.1	9.7	7.7	3.3		135	84		6	
LFKB-1	5/14/2008 10:45	413	17.6	9.1	7.8	14.1		111	71		16	
LFKB-1	6/4/2008 11:30	205	24.5	8.5	8.3	6.1		156				
LFKB-1	6/9/2008 10:50	80	27.5	7.8	8.2	5.1		206				
LFKB-1	6/11/2008 9:51	69.6	26.9	7.4	7.7	4.2		209				
LFKB-1	6/12/2008 11:00	82	27.3	7.3	8.4	6		241	132		3	
LFKB-1	6/16/2008 10:55	56	26.5	7.4	8.4	4.3		253				
LFKB-1	6/23/2008 10:00	26	25.9	7	8.3	3		297				
LFKB-1	7/10/2008 10:30	13	28	6.5	7.8	3.2		375	209		2	
LFKB-1	8/4/2008 10:30	13	28.3	8	8.2	1.7		452				
LFKB-1	8/7/2008 10:30	14	28.6	8	8.4	1.8		541	310		4	
LFKB-1	8/11/2008 10:35	9.6	26.3	8.5	8.8	1.6		544				
LFKB-1	8/18/2008 10:45	12	24.7	10	8.2	1.5		515				
LFKB-1	8/20/2008 10:30	10	25.8	9.6	8.7	1.8		507				
LFKB-1	9/3/2008 10:30	83	25.4	7.9	7	2.5		213	114		3	
LFKB-1	10/14/2008 10:50	18	21.2	8.6	8.1	2		476	289		5	
LFKB-1	11/5/2008 10:15	10	12.9	10.4	8.3	1.3		472	324		2	
LFKB-1	4/12/2012 10:25	106.9	15	10.2	7.7	2.7		166.2	114		1	
LFKB-1	5/3/2012 10:44	51.3	23.8	7.2	7.3	2.4		213.3	122		1	< MDL 1
LFKB-1	6/21/2012 8:16		25.3	6.8	7.7	2		107				
LFKB-1	7/19/2012 10:14	180.3	27.2	7.4	7.2	7.4		202	140		12	
LFKB-1	8/14/2012 15:25	101.1	25.9	8.2	7.2	9.5		242.2	198		2	
LFKB-1	8/16/2012 11:35	63										
LFKB-1	9/12/2012 15:41	78.8	23.4	8.6	8	4.6		183	98		1	
LFKB-1	10/10/2012 15:37	130.6	16.8	10.3	7.9	3.9		165	86		7	
LFKB-1	11/14/2012 13:36	122.4	9.8	11.8	7.9	8.1		219.9	168		1	< MDL 1
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LFKB-2	5/3/2012 9:42	104.4	25.4	6.9	7.7	3.1		199.9	106		1	< MDL 1
LFKB-2	6/7/2012 9:13	100	25.4	7	7.4	3.9		231.1	128		1	
LFKB-2	6/20/2012 14:48		29.8	9.7	8.5	2.8		53.8				
LFKB-2	7/19/2012 9:10	79.4	27.6	6.4	7	4.1		201.6	144		6	
LFKB-2	8/14/2012 13:37	157.9	26.6	7.6	6.9	24.7		139.9	124		2	
LFKB-2	9/12/2012 14:07	97.2	26.4	9.2	8.4	5.8		143	74		4	JQ6

STATION	VISIT_DATE	Flow cfs	Temp, Water c	Dissolved Oxygen mg/l	pH su	Turbidity ntu	Hardness mg/l	Conductivity Âµmhos/cm	Solids,Total Dissolved mg/l	DET_COND - Solids, Total Dissolved mg/l	Solids, Total Suspended mg/l	DET_COND - Solids, Total Suspended mg/l
LFKB-2	10/10/2012 13:10	150.3	18.5	11.5	8.6	3.8		155.1	90		6	
LFKB-2	11/14/2012 11:48	219.6	10.2	11.8	7.8	3.2		230.6	162		1	< MDL 1
LFKB-8	4/16/2008 13:40		16.1	11.8	7.9	4.6		142	108		5	
LFKB-8	5/20/2008 13:16	849	21.6	8.8	7.5	15.8		143	94		15	
LFKB-8	6/11/2008 15:58	162.4	30.3	8.8	8.1	5		193.7				
LFKB-8	6/25/2008 10:15	91	27.6	9.2	7.8	6.2		227	125		3	
LFKB-8	7/7/2008 11:12	76	29.1	8.1	7.6	6.7		216				
LFKB-8	7/16/2008 9:00	67	28	6.6	7.6	5.4		241				
LFKB-8	7/21/2008 9:00	37	28.8	6.9	7.7	6		260				
LFKB-8	7/23/2008 9:35	34	28.4	6.7	7.5	4.7		258	153		2	
LFKB-8	8/28/2008 9:15	2070	23.1	7.1	7.3	65		108	85		66	
LFKB-8	9/8/2008 9:10	63	25.6	7.3	7.6	5.4		211				
LFKB-8	9/17/2008 9:20	45	23.3	8.1	7.9	4.8		222	135		2	
LFKB-8	9/23/2008 9:35	36	22.7	7.9	7.8	4.1		242				
LFKB-8	9/25/2008 9:09	32	21.6	8	7.8	3.2		245				
LFKB-8	10/23/2008 9:45	27	16.4	9.7	7.8	3.7	130	303	170		5	
LFKB-8	11/6/2008 9:45	25	11.9	10.8	7.8	2.3		365	234		2	
LFKB-8	4/11/2012 14:55	374	20	10.6	7.8	2.8		168.8	98		1	< MDL 1
LFKB-8	5/2/2012 14:16	113.5	26.3	10	7.9	3	88	219.5	118		1	< MDL 1
LFKB-8	6/6/2012 14:16	230.4	27	11.7	8.4	8.9		219.4	178		12	
LFKB-8	6/20/2012 11:43		27.3	8.1	7.8	4		102.4				
LFKB-8	7/18/2012 13:23	88.8	27.9	6.7	6.9	8.4	68.1	190.1	100		4	
LFKB-8	8/14/2012 11:55	136.1	25.5	6.7	6.7	34.1		140.6	140		17	
LFKB-8	9/12/2012 12:24	144.5	23.7	8.2	7.6	11.4	71.5	183.8	104		9	
LFKB-8	10/10/2012 11:26	199.6	16.9	10.2	7.9	6.6		171.7	90		11	
LFKB-8	11/14/2012 10:42	310.3	9.9	10.8	7.3	5.8	86.2	221.8	174		4	
LFKJ-2	4/16/2008 11:40		14.9	10.6	7.6	6		142	86		5	
LFKJ-2	5/20/2008 12:15		21.4	8.6	7.5	18.8		145	96		41	
LFKJ-2	6/25/2008 11:45		28.1	9.5	8.1	5.6		233	137		5	
LFKJ-2	7/7/2008 12:10	96.1	29.4	8.6	7.6	5.8		217				
LFKJ-2	7/16/2008 9:45	90.6	28.5	7.1	7.6	12.6		82				
LFKJ-2	7/21/2008 9:45	71.8	29.1	7.3	7.6	5.5		253				
LFKJ-2	7/23/2008 10:30	78.5	28.8	7	7.6	4.7		267	170		7	
LFKJ-2	8/28/2008 10:00		23.3	7	7.4	78.5		99	78		76	
LFKJ-2	9/8/2008 9:55	138.1	26.6	8.6	7.8	5.3		195				
LFKJ-2	9/17/2008 10:15	118.8	24.3	8.6	8	4.1		201	132		2	
LFKJ-2	9/23/2008 10:14	61.2	23.6	9	8.1	4.5		238				
LFKJ-2	9/25/2008 9:50	70.7	22.6	9.1	8.1	5.5		243				
LFKJ-2	10/23/2008 10:50	50.7	16.6	10.2	8	3.3	127	292	177		7	
LFKJ-2	11/6/2008 10:45	39.6	12.6		8	4		349	220		3	
LFKJ-3	4/11/2012 13:31	290.8	19.7	9.4	7.4	4	87.2	227.8	150		1	< MDL 1

STATION	VISIT_DATE	Flow cfs	Temp, Water c	Dissolved Oxygen mg/l	pH su	Turbidity ntu	Hardness mg/l	Conductivity Âµmhos/cm	Solids,Total Dissolved mg/l	DET_COND - Solids, Total Dissolved mg/l	Solids, Total Suspended mg/l	DET_COND - Solids, Total Suspended mg/l
LFKJ-3	5/2/2012 13:11	175.7	25.3	10	7.8	5.1		292.1	156		2	
LFKJ-3	6/6/2012 13:00	515.6	26.2	8.2	7.4	9.1	104	263.7	210		10	
LFKJ-3	6/20/2012 7:43		27.7	8.6	7.8	6.8		154.8				
LFKJ-3	7/18/2012 12:34		28.8	6.6	6.9	8.6		227	128		6	
LFKJ-3	8/14/2012 10:33	228.2	25.5	6.5	6.7	27.2	72.1	197.4	194		9	
LFKJ-3	9/12/2012 11:24	209.6	23.6	7.3	7.3	11.8		272.8	174		4	
LFKJ-3	10/10/2012 10:10	230.1	17	9.1	7.3	10.7	98.6	241.1	136		14	
LFKJ-3	11/14/2012 9:44	331.7	10.4	10.1	7.1	8.6		273.7	198		1	
LFKJ-5	4/24/2007 15:15		20.8	9.5	7.8	8.4	116	290.5	167		7	
LFKJ-5	5/15/2007 16:43		26	12.4	8.3	7.1		346.3	219		6	
LFKJ-5	6/19/2007 15:57		28	9.7	8.2	8.9	98.9	565.5	358		10	
LFKJ-5	7/26/2007 9:28		27.7		7.9	5.5			238		11	
LFKJ-5	8/21/2007 16:19		31.1	11.8	8.5	5.4	82.3	548.2	357		10	
LFKJ-5	9/18/2007 15:17		23.8	5.5	7.5	25.1		377.3	228		21	
LFKJ-5	10/23/2007 16:51		20.7	7.3	7.6	11.3	220	665.9	350		9	
LFKJ-5	4/18/2012 12:25		19.8	7.9	7.3	11	114	312	210		3	
LFKJ-5	5/16/2012 12:46		22.7	7.7	7.5	15.6		287.6	234		8	
LFKJ-5	6/19/2012 10:42		27.7	7.6	7.5	9.5	138	362.1	192		6	
LFKJ-5	7/25/2012 13:17		29.6	5.4	7.2	12.3		241.2	244		6	
LFKJ-5	8/21/2012 11:36		24.8	6	7.2	39.9	90	251.2	184		18	
LFKJ-5	9/19/2012 12:08		22.9	6.9	7.4	50.3		294.2	202		22	
LFKJ-5	10/16/2012 12:45		20.2	8.3	7.6	10	145	395.9	300		1	< MDL 1
LFKJ-6	6/29/2005 10:18					5	179		352	JH	6	JH
LFKJ-6	8/15/2005 10:00					4.4	137		262		5	
LFKJ-6	10/18/2005 11:18		21.3	9.1	7.8	9.2	221	548	354		5	
LFKJ-6	6/28/2006 10:40		28.6	8.6	8.1	6.4	208	531	335		8	
LFKJ-6	8/8/2006 11:20		29.8	8.6	8.5	7.6	187	500	256		8	
LFKJ-6	10/12/2006 11:15		21.7	7.4	7.9	7.5	136	349	208		11	
LFKJ-6	6/13/2007 11:40		29.6	18.8	9.3	6.1	190	566	388		11	
LFKJ-6	8/9/2007 11:40		30.8	12.3	9.1	6	153	390	285		13	
LFKJ-6	10/10/2007 11:12		24.4	9.2	8.7	6	181	456	353		7	
LFKJ-6	6/11/2008 11:00		30.3	14.5	9.1	6	130	355	220		8	
LFKJ-6	8/14/2008 10:10		28.1	4.6	7.8	8.4	191	529	357	JQ1	18	
LFKJ-6	10/14/2008 10:40		22.1	7.5	7.8	7.6	268	569	357		8	
LFKJ-6	6/17/2009 12:15		25.2	7.6	7.5	43.8	109	272	199		43	
LFKJ-6	8/19/2009 11:35		29.2	6.5	7.6	6.3	205	516	325		8	
LFKJ-6	10/21/2009 11:30		14.1	9.9	6.9	17.8	116	276	189		18	
LFKJ-6	5/5/2010 11:20		19.9	7.4	6.4	66.7	59.7	149	99		54	
LFKJ-6	7/7/2010 11:00		29.7	12.5	8.6	6.8		434	272		9	
LFKJ-6	9/8/2010 10:45		27	7.1	7.8	7.7		503	316		8	
LFKJ-6	5/19/2011 13:45		20.4	13	8.4	7	140	346	224		4	

STATION	VISIT_DATE	Flow cfs	Temp, Water c	Dissolved Oxygen mg/l	pH su	Turbidity ntu	Hardness mg/l	Conductivity Âµmhos/cm	Solids,Total Dissolved mg/l	DET_COND - Solids, Total Dissolved mg/l	Solids, Total Suspended mg/l	DET_COND - Solids, Total Suspended mg/l
LFKJ-6	7/21/2011 10:45		29.5	12	8.8	6.2		385	260		9	
LFKJ-6	9/22/2011 11:30		20.9	7.4	6.6	91.8		141	122		46	
LFKJ-6	4/18/2012 11:10		20.3	10.2	7.6	8		451.9	1	< MDL 1	4	
LFKJ-6	5/16/2012 11:26		22.4	7.7	7.7	10.1	140	363.3	288		1	< MDL 1
LFKJ-6	6/19/2012 9:24		28.2	15.6	8.9	8.1		376	212		5	
LFKJ-6	7/25/2012 12:08		29.9	9.6	8.4	6.5		367.2	392		2	
LFKJ-6	8/21/2012 10:31		24.8	5.6	7.2	92.4		286.8	242		27	
LFKJ-6	9/19/2012 10:55		24	6.7	7	12.9		387.7	234		15	
LFKJ-6	10/16/2012 11:34		20.5	10.8	8.2	5.9		441.6	290		1	< MDL 1
LFKJ-6	11/29/2012 11:30		10.4	10.8	7.8	6		515	338		5	
LFKJ-6	12/13/2012 11:20		11.4	10.2	7.6	18.7		186	125		9	
BANT-3	8/16/2005 16:30		29.3	8.2	7.7	6.7	203	467.9	267		7	
BANT-3	4/19/2006 11:25		22.8	11.4	8.5	7.8		285.7	184		13	
BANT-3	5/17/2006 11:41		19.6	7.8	7.4	14.9		183.3	102		13	
BANT-3	6/21/2006 11:33		29	6.4	7.4	11.2		452.3	267		10	
BANT-3	7/19/2006 11:13		30.9	5.7	7.4	6.4		544.7	410		6	
BANT-3	8/24/2006 12:16		30.7	8.3	8.3	10		501.8	256		10	
BANT-3	9/20/2006 11:46		26.2	9.5	8.7	10.1		483.6	278		12	
BANT-3	10/19/2006 12:35		20.4	7.1	7.7	10.6		415.6	224		11	
BANT-3	4/17/2007 16:01		19.5	9.8	7.6	5.9	129	323.2	200		7	
BANT-3	5/15/2007 13:51		25.6	8.7	7.7	5.9		304.5	200		8	
BANT-3	6/19/2007 15:49		28.3	7	8.2	7.7	103	492.4	300		9	
BANT-3	7/25/2007 14:35		29.2	6.2	8	7.2		559.2	308		8	
BANT-3	8/21/2007 13:29		31.3	6.3	8	8.6	89.8	485.7	364		12	
BANT-3	9/18/2007 13:43		27.6	10.2	8.7	8.3		607.8	335		9	
BANT-3	10/23/2007 14:10		22.6	6.6	8	10.3	189	500.3	256		13.4	
BANT-3	8/12/2009 11:15		29.5	9.4	8.1	6.4	147	421.6	250		6	
BANT-3	4/20/2011 11:22		17.1	8.5	7.2	14	61.1	169.6	98		4	
BANT-3	5/18/2011 14:06		22.3	7.9	7.6	16.6		392.3	260		19	
BANT-3	6/23/2011 10:48		29.7	5	7.5	5.5	239	605.5	370		2	
BANT-3	7/20/2011 11:00		30.8	9.3	8.2	7.5		416.1	376		5	
BANT-3	8/24/2011 13:17		31.2	7.1	7.8	6.5	206	490.4	342		3	
BANT-3	9/22/2011 10:53		21.5	6.5	7.1	102		159.3	154		41	
BANT-3	10/13/2011 11:45		21	7.8	7.4	10.1	167	413.6	246		3	
BANT-3	4/18/2012 16:02		21.7	8.8	7.8	5.9	159	395.5	274		7	
BANT-3	5/16/2012 15:11		24.6	9.2	7.8	5.8		404.7	296		1	< MDL 1
BANT-3	6/19/2012 14:19		28.1	9.3	8.2	7.4	199	495.7	300		4	
BANT-3	7/25/2012 14:37		33	14.4	8.6	7.2		583.6	370		4	
BANT-3	8/22/2012 15:18		27.9	10.4	8.4	11.1	150	397.1	262		11	
BANT-3	9/19/2012 15:20		25.6	7.6	7.8	7.8		402.4	276		1	< MDL 1
BANT-3	10/16/2012 14:22		21.5	9.2	7.9	5.9	137	341.4	208		2	

STATION	VISIT_DATE	Flow cfs	Temp, Water c	Dissolved Oxygen mg/l	pH su	Turbidity ntu	Hardness mg/l	Conductivity Âµmhos/cm	Solids,Total Dissolved mg/l	DET_COND - Solids, Total Dissolved mg/l	Solids, Total Suspended mg/l	DET_COND - Solids, Total Suspended mg/l
VLGJ-5	6/29/2005 11:50		27	9.2	8.4	13.5	210	503	390	JH	19	JH
VLGJ-5	8/15/2005 11:15	109.2	27.7	10.1	8	6.1	312	724	588		5	
VLGJ-5	10/18/2005 12:00	59.1	17.5	11.4	8.2	1.6	307	682	461		1	< MDL 1
VLGJ-5	6/28/2006 9:38	66.3	25.3	7.8	8	3.5	296	688	328		4	
VLGJ-5	8/8/2006 10:30	62.9	28.4	8	8.8	9.6	258	614	398		13	
VLGJ-5	10/12/2006 10:00	55.8	18.8	9.8	8.9	7.5	250	549	352		15	
VLGJ-5	3/15/2007 11:25	89.8	17.6	10.5	8.2	1.8		621	456		7	
VLGJ-5	4/3/2007 11:30	78.2	21.3	8	7.8	3.6	278	666	472		3	
VLGJ-5	5/10/2007 11:25	62	22.9	8.8	8.1	2.2		629	408		4	
VLGJ-5	6/13/2007 10:45	50.9	26.3	9.3	8.7	3.2	266	687	439		7	
VLGJ-5	7/10/2007 12:55	76.2	27.7	9.3	8.4	5.6		543	394		6	
VLGJ-5	8/9/2007 10:57	47.7	29.5	9	8.7	8.4	203	462	354		12	
VLGJ-5	9/4/2007 12:25	45.8	27.2	10.9	8.9	9.7		485	412		14	
VLGJ-5	10/10/2007 10:20	84.8	22.2	8.8	8.6	8.8	205	497	407		12	
VLGJ-5	6/11/2008 10:25		28.2	7.8	8.2	8.6	194	493	295		13	
VLGJ-5	8/14/2008 9:30		24.4	8.8	8.8	12.1	186	495	339	JQ1	17	
VLGJ-5	10/14/2008 9:55		20.8	9.4	8.1	3.9	350	654	439		3	
VLGJ-5	6/17/2009 11:20		24.9	8.9	7.8	12.3	185	420	298		16	
VLGJ-5	8/19/2009 10:50		26.5	8.3	8.1	3.4	328	706	476		4	
VLGJ-5	10/21/2009 10:45		15.5	10.2	7.9	3.6	358	689	519		4	
VLGJ-5	5/5/2010 13:00		21.9	9.1	7.3	8.9	170	382	240		6	
VLGJ-5	7/7/2010 12:20	69.4	28.6	9.1	8.2	3.8		655	426		3	
VLGJ-5	9/8/2010 12:45	67.2	26.2	13.2	9.2	14.8		616	414		22	
VLGJ-5	5/19/2011 11:15	75.5	18.8	10.8	8	2.1	327	700	482		1	
VLGJ-5	7/21/2011 12:15		27.9	7.4	8.4	30.2		362	237		49	
VLGJ-5	9/22/2011 13:00		22.9	9.7	7.8	7.4		481	312		7	
VLGJ-5	4/25/2012 10:00	80.6	16.7	10	8.1	2.1		651	447	JH	3	JH
VLGJ-5	5/23/2012 13:15	94.9	25	10.1	8.3	3.8	216	493	332		4	
VLGJ-5	6/25/2012 10:20	63.1	28	7.9	8.1	2.8		700	452		4	
VLGJ-5	7/18/2012 10:20		27.6	8.3	8.6	8.6		553	362		12	
VLGJ-5	8/30/2012 13:50	82.3	26.4	9.4	8.6	8.8		526	330		9	
VLGJ-5	9/27/2012 12:50	84.6	22.8	10.6	8.4	2.7		537	361		5	
VLGJ-5	10/24/2012 10:15	93.1	16.9	9.8	8.4	1.6		555	374		1	< MDL 1
VLGJ-5	11/28/2012 10:45	116.5	11.2	12.6	8.3	1.8		471	301		2	
VLGJ-5	12/6/2012 10:00	80	14.4	10.9	8	1.2		550	343		1	

STATION	VISIT_DATE	Alk,Total mg/l	DET_COND - Alk,Total mg/l	Clorides, Total mg/l	DET_COND - Clorides, Total mg/l	Nitrogen, Ammonia mg/l	DET_COND - Nitrogen, Ammonia mg/l	Nitrogen, NO2+NO3 mg/l	DET_COND - Nitrogen, NO2+NO3 mg/l	Nitrogen, Total Kjeldahl mg/l	DET_COND - Nitrogen, Total Kjeldahl mg/l
LFKB-15	4/12/2012 11:41	58.2		2.4		0.007	< MDL .007	0.355		0.334	
LFKB-15	5/2/2012 14:34										
LFKB-15	5/3/2012 11:50	87.6		2.3		0.007	< MDL .007	0.363		0.238	
LFKB-15	6/7/2012 11:21	55.3		2.2		0.008	< MDL .008	0.343		0.284	
LFKB-15	7/19/2012 11:31	81.3		2.2		0.069		0.341		0.245	
LFKB-15	8/14/2012 17:15	73.7		2.2		0.008	< MDL .008	0.244		0.401	
LFKB-15	9/12/2012 16:47	99.7		2.8		0.008	< MDL .008	0.308		0.216	
LFKB-15	10/10/2012 16:54	71.3		3.4		0.053		0.348		0.051	JI
LFKB-15	11/14/2012 14:44	66.2		3.9		0.008	< MDL .008	0.138		0.178	
LFKB-1	4/22/2008 11:40	41.5		5.7		0.015	< MDL .015	0.956		1.6	
LFKB-1	5/14/2008 10:45	28		4.2		0.015	< MDL .015	1.3		0.887	
LFKB-1	6/4/2008 11:30										
LFKB-1	6/9/2008 10:50										
LFKB-1	6/11/2008 9:51										
LFKB-1	6/12/2008 11:00	58.9		12.6		0.015	< MDL .015	1.56		0.999	
LFKB-1	6/16/2008 10:55										
LFKB-1	6/23/2008 10:00										
LFKB-1	7/10/2008 10:30	93.9		27.3		0.015	< MDL .015	2.56		1.82	
LFKB-1	8/4/2008 10:30										
LFKB-1	8/7/2008 10:30	118.2		42		0.092		5.36		0.06	< MDL .06
LFKB-1	8/11/2008 10:35										
LFKB-1	8/18/2008 10:45										
LFKB-1	8/20/2008 10:30										
LFKB-1	9/3/2008 10:30	45.2		8.3		0.015	< MDL .015	1.52		0.303	
LFKB-1	10/14/2008 10:50	83.5		48		0.01	< MDL .01	2.45		2.1	
LFKB-1	11/5/2008 10:15	102.6		33		0.051		9.18		0.1	< MDL .1
LFKB-1	4/12/2012 10:25	41.2		6.2		0.007	< MDL .007	1.841		0.348	
LFKB-1	5/3/2012 10:44	58.4		10.5		0.007	< MDL .007	2.223		0.425	
LFKB-1	6/21/2012 8:16										
LFKB-1	7/19/2012 10:14	51.2		8.8		0.049		1.817		0.415	
LFKB-1	8/14/2012 15:25	49.8		14.9		0.008	< MDL .008	5.311		0.653	
LFKB-1	8/16/2012 11:35										
LFKB-1	9/12/2012 15:41	42.7		9.9		0.008	< MDL .008	3.859		0.404	
LFKB-1	10/10/2012 15:37	43.3		8.4		0.008	< MDL .008	2.858		0.081	JI
LFKB-1	11/14/2012 13:36	56.3		11.8		0.008	< MDL .008	3.072		0.557	
LFKB-2	4/12/2012 9:17	48.4		4.6		0.007	< MDL .007	0.895		0.344	
LFKB-2	5/3/2012 9:42	65.1		6.9		0.007	< MDL .007	0.778		0.558	
LFKB-2	6/7/2012 9:13	76.9		8.4		0.008	< MDL .008	0.859		0.368	
LFKB-2	6/20/2012 14:48										
LFKB-2	7/19/2012 9:10	45.7		9.3		0.035		1.438		0.542	
LFKB-2	8/14/2012 13:37	40.3		3.5		0.05		0.815		0.534	
LFKB-2	9/12/2012 14:07	45.1		5		0.008	< MDL .008	1.127		0.58	

STATION	VISIT_DATE	Alk,Total mg/l	DET_COND - Alk,Total mg/l	Clorides, Total mg/l	DET_COND - Clorides, Total mg/l	Nitrogen, Ammonia mg/l	DET_COND - Nitrogen, Ammonia mg/l	Nitrogen, NO2+NO3 mg/l	DET_COND - Nitrogen, NO2+NO3 mg/l	Nitrogen,Total Kjeldahl mg/l	DET_COND - Nitrogen, Total Kjeldahl mg/l
LFKB-2	10/10/2012 13:10	50		6.6		0.008	< MDL .008	1.174		0.133	JI
LFKB-2	11/14/2012 11:48	74.1	JQ	10.5		0.008	< MDL .008	2.422		0.358	
LFKB-8	4/16/2008 13:40	53.5		4.6		0.015	< MDL .015	0.656		1.23	
LFKB-8	5/20/2008 13:16	45.1		3.3		0.015	< MDL .015	0.679		0.762	
LFKB-8	6/11/2008 15:58										
LFKB-8	6/25/2008 10:15	75.8		6.8		0.015	< MDL .015	0.003	< MDL .003	1.21	
LFKB-8	7/7/2008 11:12										
LFKB-8	7/16/2008 9:00										
LFKB-8	7/21/2008 9:00										
LFKB-8	7/23/2008 9:35	90.9		8.9		0.079		0.023		0.536	
LFKB-8	8/28/2008 9:15	29.7		2.8		0.015	< MDL .015	0.514		1	
LFKB-8	9/8/2008 9:10										
LFKB-8	9/17/2008 9:20	72.2		8.2		0.01	< MDL .01	0.187		0.227	
LFKB-8	9/23/2008 9:35										
LFKB-8	9/25/2008 9:09										
LFKB-8	10/23/2008 9:45	113.9		12.1		0.01	< MDL .01	0.267		0.545	
LFKB-8	11/6/2008 9:45	116.2		18		0.091		1.18		0.476	
LFKB-8	4/11/2012 14:55	48.5		3.9		0.007	< MDL .007	0.694		0.234	
LFKB-8	5/2/2012 14:16	70		5.9		0.007	< MDL .007	0.52		0.285	
LFKB-8	6/6/2012 14:16	79.9		7.8		0.008	< MDL .008	0.002	< MDL .002	0.294	
LFKB-8	6/20/2012 11:43										
LFKB-8	7/18/2012 13:23	50.4		5.1		0.028		0.617		0.451	
LFKB-8	8/14/2012 11:55	42.2		3.2		0.055		0.476		0.865	
LFKB-8	9/12/2012 12:24	60		3.6		0.008	< MDL .008	0.846		0.36	
LFKB-8	10/10/2012 11:26	55.9		5.4		0.008	< MDL .008	0.754		0.085	JI
LFKB-8	11/14/2012 10:42	74.9		9		0.008	< MDL .008	1.5		0.324	
LFKJ-2	4/16/2008 11:40	50.2		4.2		0.015	< MDL .015	0.726		1.3	
LFKJ-2	5/20/2008 12:15	44.4		3.5		0.015	< MDL .015	0.692		0.807	
LFKJ-2	6/25/2008 11:45	83.7		6.3		0.015	< MDL .015	0.003	< MDL .003	1.38	
LFKJ-2	7/7/2008 12:10										
LFKJ-2	7/16/2008 9:45										
LFKJ-2	7/21/2008 9:45										
LFKJ-2	7/23/2008 10:30	113.9		11.3		0.015	< MDL .015	0.467		0.474	
LFKJ-2	8/28/2008 10:00	27.8		2.9		0.015	< MDL .015	0.465		1.29	
LFKJ-2	9/8/2008 9:55										
LFKJ-2	9/17/2008 10:15	67.3		9.4		0.01	< MDL .01	0.182		0.259	
LFKJ-2	9/23/2008 10:14										
LFKJ-2	9/25/2008 9:50										
LFKJ-2	10/23/2008 10:50	111.8		10.6		0.01	< MDL .01	0.171		0.389	
LFKJ-2	11/6/2008 10:45	117.6		14.8		0.162		0.788		0.286	
LFKJ-3	4/11/2012 13:31	61.1		3.6		0.007	< MDL .007	0.631		0.31	

STATION	VISIT_DATE	Alk,Total mg/l	DET_COND - Alk,Total mg/l	Clorides, Total mg/l	DET_COND - Clorides, Total mg/l	Nitrogen, Ammonia mg/l	DET_COND - Nitrogen, Ammonia mg/l	Nitrogen, NO2+NO3 mg/l	DET_COND - Nitrogen, NO2+NO3 mg/l	Nitrogen,Total Kjeldahl mg/l	DET_COND - Nitrogen, Total Kjeldahl mg/l
LFKJ-3	5/2/2012 13:11	85.3		5.4		0.007	< MDL .007	0.484		0.214	
LFKJ-3	6/6/2012 13:00	87		5.3		0.008	< MDL .008	0.191		0.334	
LFKJ-3	6/20/2012 7:43										
LFKJ-3	7/18/2012 12:34	59.6		5.2		0.032		0.566		0.326	
LFKJ-3	8/14/2012 10:33	50.8		4.1		0.008	< MDL .008	0.597		0.712	
LFKJ-3	9/12/2012 11:24	68.8		3.5		0.008	< MDL .008	0.691		0.215	
LFKJ-3	10/10/2012 10:10	70.4		5.3		0.009	JI	0.787		0.041	< MDL .041
LFKJ-3	11/14/2012 9:44	87.2		6.9		0.008	< MDL .008	0.936		0.424	
LFKJ-5	4/24/2007 15:15	68.4		6.7	JH	0.015	< MDL .015	0.914		0.456	
LFKJ-5	5/15/2007 16:43	79.9		9.5		0.015	< MDL .015	0.803		1.012	
LFKJ-5	6/19/2007 15:57	112.1		15.8		0.063		0.273		0.624	
LFKJ-5	7/26/2007 9:28	87		16.2	JH	0.015	< MDL .015	0.444		0.815	
LFKJ-5	8/21/2007 16:19	101.7		21.4		0.015	< MDL .015	0.007	JI	1.565	
LFKJ-5	9/18/2007 15:17	93.3		9.3		0.04		0.645		0.59	
LFKJ-5	10/23/2007 16:51	122.1		23.9		0.015	< MDL .015	1.56		0.458	
LFKJ-5	4/18/2012 12:25	74		6.3		0.01	JI	0.835		0.688	
LFKJ-5	5/16/2012 12:46	83.1		5.2		0.008	< MDL .008	0.59		0.093	JI
LFKJ-5	6/19/2012 10:42	89		7.6		0.008	< MDL .008	0.408		0.234	
LFKJ-5	7/25/2012 13:17	59		3.9		0.008	< MDL .008	0.577		0.497	
LFKJ-5	8/21/2012 11:36	55.7	JQ	3.5		0.05		0.512		0.335	
LFKJ-5	9/19/2012 12:08	77.4		3.6		0.008	< MDL .008	0.519		0.168	
LFKJ-5	10/16/2012 12:45	92.3		7.5		0.008	< MDL .008	0.907		0.206	
LFKJ-6	6/29/2005 10:18	93.7				0.015	< MDL .015	0.481		0.464	
LFKJ-6	8/15/2005 10:00	78.6				0.015	< MDL .015	0.649		0.533	
LFKJ-6	10/18/2005 11:18	117.5				0.015	< MDL .015	1.3		0.659	
LFKJ-6	6/28/2006 10:40	109.1		13.2		0.084		0.514		1.24	
LFKJ-6	8/8/2006 11:20	98.9		12.8		0.015	< MDL .015	0.242		1.54	
LFKJ-6	10/12/2006 11:15	80.6		9.7		0.043		0.664		1.01	
LFKJ-6	6/13/2007 11:40	83		16.8		0.015	< MDL .015	0.012		1.307	
LFKJ-6	8/9/2007 11:40	86.6		18.1		0.015	< MDL .015	0.005	JI	0.758	
LFKJ-6	10/10/2007 11:12	94.2		34.7		0.015	< MDL .015	0.023		0.433	
LFKJ-6	6/11/2008 11:00	52.9		33		0.015	< MDL .015	0.003	< MDL .003	1.51	
LFKJ-6	8/14/2008 10:10	118.6		18.4		0.204		0.281		1.14	
LFKJ-6	10/14/2008 10:40	125.8		23.7		0.01	< MDL .01	0.571		2.14	
LFKJ-6	6/17/2009 12:15	61.4		5.8			Not Reported .1, RQ	3.466	JQ		Not Reported .1,RQ
LFKJ-6	8/19/2009 11:35	112		17.1			Not Reported .1, RQ	16.41	JQ		Not Reported .1,RQ
LFKJ-6	10/21/2009 11:30	69.8		3.1			Not Reported .1, RQ	6.62	JB		Not Reported .1,RQ
LFKJ-6	5/5/2010 11:20	33.3		3.1			Not Reported .015, RQ	0.552			Not Reported .1,RQ
LFKJ-6	7/7/2010 11:00	69.4		33.3			Not Reported .02, RQ	0.714			Not Reported .1,RQ
LFKJ-6	9/8/2010 10:45	84.2		30.2			Not Reported .015, RQ	0.727			Not Reported .1,RQ
LFKJ-6	5/19/2011 13:45	60		16.8		0.5	JQL	0.874	JH		Not Reported .15,RQ

STATION	VISIT_DATE	Alk,Total mg/l	DET_COND - Alk,Total mg/l	Clorides, Total mg/l	DET_COND - Clorides, Total mg/l	Nitrogen, Ammonia mg/l	DET_COND - Nitrogen, Ammonia mg/l	Nitrogen, NO2+NO3 mg/l	DET_COND - Nitrogen, NO2+NO3 mg/l	Nitrogen,Total Kjeldahl mg/l	DET_COND - Nitrogen, Total Kjeldahl mg/l
LFKJ-6	7/21/2011 10:45	66.2		21.1		0.5	JQL	0.602	JQ		Not Reported .15,RQ
LFKJ-6	9/22/2011 11:30	24.3		10.7		0.5	JQL	0.394			Not Reported .15,RQ
LFKJ-6	4/18/2012 11:10	84.2		7		0.007	< MDL .007	0.902		0.836	
LFKJ-6	5/16/2012 11:26	90.4		9.8		0.016	JI	1.196		0.313	
LFKJ-6	6/19/2012 9:24	88.3		7.9		0.008	< MDL .008	0.081		0.683	
LFKJ-6	7/25/2012 12:08	79.1		9.5		0.008	< MDL .008	0.875		0.55	
LFKJ-6	8/21/2012 10:31	54.8		4.4		0.015		0.559		0.39	
LFKJ-6	9/19/2012 10:55	98.6		8.3		0.035		1.186		0.504	
LFKJ-6	10/16/2012 11:34	99.3		8.2		0.008	< MDL .008	1.327		0.496	
LFKJ-6	11/29/2012 11:30	81.1		13.1		0.028	< MDL .028	1.86		0.412	JQ4
LFKJ-6	12/13/2012 11:20	21.8		3.8		0.028	< MDL .028	0.703		0.505	
BANT-3	8/16/2005 16:30	84.8		9.9		0.015	< MDL .015	0.792		0.753	
BANT-3	4/19/2006 11:25	59		1.5		0.029		0.943		0.829	
BANT-3	5/17/2006 11:41	43.8		1.4		0.037		0.789		0.365	
BANT-3	6/21/2006 11:33	96.2		9.1		0.065		0.502		0.745	
BANT-3	7/19/2006 11:13	112.6		13.9		0.061		0.304		1.02	
BANT-3	8/24/2006 12:16	106.8		10.9		0.015	< MDL .015	0.003	< MDL .003	1.44	
BANT-3	9/20/2006 11:46	119.3		2.6		0.015	< MDL .015	0.003		0.747	
BANT-3	10/19/2006 12:35	58		13.4		0.06		0.621		0.584	
BANT-3	4/17/2007 16:01	72.6		55.9	JH	0.015	< MDL .015	0.919		0.561	
BANT-3	5/15/2007 13:51	70.3		7.6		0.041		0.601		0.567	
BANT-3	6/19/2007 15:49	103.9		12.8		0.034		0.089		0.723	
BANT-3	7/25/2007 14:35	115.2		18.7	JH	0.02		0.327		0.702	
BANT-3	8/21/2007 13:29	101.3		17.1		0.015	< MDL .015	0.053		0.513	
BANT-3	9/18/2007 13:43	113.9		23.1		0.015	< MDL .015	0.529		0.657	
BANT-3	10/23/2007 14:10	105.4		15.5		0.061		0.515		0.906	
BANT-3	8/12/2009 11:15	92.7		7.3		0.039		0.622		0.626	
BANT-3	4/20/2011 11:22	35		3		0.005	< MDL .005	0.827		0.7	
BANT-3	5/18/2011 14:06	75		5.5		0.005	< MDL .005	0.693		0.719	
BANT-3	6/23/2011 10:48	97.1		8.4		0.005	< MDL .005	0.605		0.282	
BANT-3	7/20/2011 11:00	84.1		8		0.005	< MDL .005	0.567		0.68	
BANT-3	8/24/2011 13:17	92.9		7.9		0.031		0.208		0.546	
BANT-3	9/22/2011 10:53	44		2.5		0.005	< MDL .005	0.569		0.835	
BANT-3	10/13/2011 11:45	70.6		5.6		0.007	< MDL .007	1.017		0.591	
BANT-3	4/18/2012 16:02	78.4		5.7		0.121		0.595		0.703	
BANT-3	5/16/2012 15:11	84.1		6.6		0.008	< MDL .008	0.746		0.636	
BANT-3	6/19/2012 14:19	105		9.2		0.008	< MDL .008	0.271		0.553	
BANT-3	7/25/2012 14:37	116		12.9		0.008	< MDL .008	0.153		0.844	
BANT-3	8/22/2012 15:18	93.3		7.2		0.008	< MDL .008	0.363		0.512	
BANT-3	9/19/2012 15:20	82.2		6.3		0.065		0.936		0.313	
BANT-3	10/16/2012 14:22	73.9		6		0.008	< MDL .008	0.929		0.172	

STATION	VISIT_DATE	Alk,Total mg/l	DET_COND - Alk,Total mg/l	Clorides, Total mg/l	DET_COND - Clorides, Total mg/l	Nitrogen, Ammonia mg/l	DET_COND - Nitrogen, Ammonia mg/l	Nitrogen, NO2+NO3 mg/l	DET_COND - Nitrogen, NO2+NO3 mg/l	Nitrogen,Total Kjeldahl mg/l	DET_COND - Nitrogen, Total Kjeldahl mg/l
VLGJ-5	6/29/2005 11:50	150.5				0.015	< MDL .015	3.17		0.962	
VLGJ-5	8/15/2005 11:15	144.6				0.015	< MDL .015	2.789		0.324	
VLGJ-5	10/18/2005 12:00	134.4				0.015	< MDL .015	3.77		0.478	
VLGJ-5	6/28/2006 9:38	136.8		20.2		0.022		2.857		0.848	
VLGJ-5	8/8/2006 10:30	119.5		16.2		0.015	< MDL .015	1.11		1.18	
VLGJ-5	10/12/2006 10:00	127.9		14.8		0.015	< MDL .015	1.132		1.45	
VLGJ-5	3/15/2007 11:25	136.8		14.6		0.031		4.045		0.829	
VLGJ-5	4/3/2007 11:30	131.8		16.4		0.108		4.162		0.543	
VLGJ-5	5/10/2007 11:25	126.7		17.4		0.022		2.82		0.566	
VLGJ-5	6/13/2007 10:45	131		22.6		0.015	< MDL .015	2.69	JB	0.855	
VLGJ-5	7/10/2007 12:55	113		23.5		0.015	< MDL .015	2.83		0.764	
VLGJ-5	8/9/2007 10:57	111		20.6		0.015	< MDL .015	1.45		0.721	
VLGJ-5	9/4/2007 12:25	70.4		91.9		0.015	< MDL .015	2		2.66	JH
VLGJ-5	10/10/2007 10:20	104.2		43.5		0.015	< MDL .015	1.3		0.712	
VLGJ-5	6/11/2008 10:25	133.1		14.9		0.015	< MDL .015	0.763		1.24	
VLGJ-5	8/14/2008 9:30	75.5		48.2		0.088		0.979		1.76	
VLGJ-5	10/14/2008 9:55	136.2		30.1		0.01	< MDL .01	1.16		2.03	
VLGJ-5	6/17/2009 11:20	86		6.1			Not Reported .1, RQ	7.56	JQ		Not Reported .1,RQ
VLGJ-5	8/19/2009 10:50	147		23.2			Not Reported .1, RQ	5.58	JQ		Not Reported .1,RQ
VLGJ-5	10/21/2009 10:45	157		11.4			Not Reported .1, RQ	14.247	JB		Not Reported .1,RQ
VLGJ-5	5/5/2010 13:00	77.4		5			Not Reported .015, RQ	1.653			Not Reported .1,RQ
VLGJ-5	7/7/2010 12:20	95.8		36.1			Not Reported .015, RQ	1.139			Not Reported .1,RQ
VLGJ-5	9/8/2010 12:45	79.7		54.1			Not Reported .015, RQ	1.415			Not Reported .1,RQ
VLGJ-5	5/19/2011 11:15	129.9		18.3			Not Reported .02, RQ	2.96	JH		Not Reported .15,RQ
VLGJ-5	7/21/2011 12:15	70.9		24.5		0.5	JQL	0.953	JQ		Not Reported .15,RQ
VLGJ-5	9/22/2011 13:00	78.9		22		0.5	JQL	2.27			Not Reported .15,RQ
VLGJ-5	4/25/2012 10:00	115		11.5		0.011	JH	6.11	JH	0.559	
VLGJ-5	5/23/2012 13:15	78.2		9.7		0.01	< MDL .01	1.48		0.649	
VLGJ-5	6/25/2012 10:20	109		11.6		0.01	< MDL .01	1.92		0.73	
VLGJ-5	7/18/2012 10:20	94.4		18		0.028	< MDL .028, JH	2.21	JH	1.26	
VLGJ-5	8/30/2012 13:50	85.9		11.9		0.028	< MDL .028	1.75		1.18	
VLGJ-5	9/27/2012 12:50		Not Reported 10,X	7.5		0.028	< MDL .028	1.72		0.533	
VLGJ-5	10/24/2012 10:15	94		10.2		0.028	< MDL .028, JQ4	2.73		0.426	
VLGJ-5	11/28/2012 10:45	92.5		15.2		0.028	< MDL .028	3.37		0.59	
VLGJ-5	12/6/2012 10:00	98		15.1		0.028	< MDL .028	3.99		0.57	

STATION	VISIT_DATE	Phosphorus, Dissolved Reactive mg/l	DET_COND - Phosphorus, Dissolved Reactive mg/l	Phosphorus, Total mg/l	DET_COND - Phosphorus, Total mg/l	Chlorophyll a mg/m^3	DET_COND - Chlorophyll a mg/m^3	CBOD-5 mg/l	DET_COND - CBOD-5 mg/l
LFKB-15	4/12/2012 11:41	0.006	JI	0.02		0.27		2.4	JQ
LFKB-15	5/2/2012 14:34								
LFKB-15	5/3/2012 11:50	0.008	JI	0.023		1.07		2.8	JQ
LFKB-15	6/7/2012 11:21	0.007	JI	0.028		0.71		2	< MDL 2
LFKB-15	7/19/2012 11:31	0.008	JI	0.029		0.53		2	< MDL 2
LFKB-15	8/14/2012 17:15	0.016		0.079		1.78		2	< MDL 2
LFKB-15	9/12/2012 16:47	0.007	JI	0.023		2.14		2	< MDL 2
LFKB-15	10/10/2012 16:54	0.006	JI	0.02		0.1	< MDL .1	2	< MDL 2
LFKB-15	11/14/2012 14:44	0.005	JI	0.028		0.27		2	< MDL 2
LFKB-1	4/22/2008 11:40	0.226		0.233		1	< MDL 1	1	< MDL 1
LFKB-1	5/14/2008 10:45	0.104		0.147		1	< MDL 1	1	< MDL 1
LFKB-1	6/4/2008 11:30								
LFKB-1	6/9/2008 10:50								
LFKB-1	6/11/2008 9:51								
LFKB-1	6/12/2008 11:00	0.508		0.48		1	< MDL 1	1	< MDL 1
LFKB-1	6/16/2008 10:55								
LFKB-1	6/23/2008 10:00								
LFKB-1	7/10/2008 10:30	0.914		0.865		1	< MDL 1	1	< MDL 1
LFKB-1	8/4/2008 10:30								
LFKB-1	8/7/2008 10:30	1.1		1.09		1	< MDL 1	1	< MDL 1
LFKB-1	8/11/2008 10:35								
LFKB-1	8/18/2008 10:45								
LFKB-1	8/20/2008 10:30								
LFKB-1	9/3/2008 10:30	0.284		0.234		1	< MDL 1	1	< MDL 1
LFKB-1	10/14/2008 10:50	2.24		1.88		1	< MDL 1	1	< MDL 1
LFKB-1	11/5/2008 10:15	6.27		5.93		1	< MDL 1	1	< MDL 1
LFKB-1	4/12/2012 10:25	0.238		0.267		1.07		2.5	JQ
LFKB-1	5/3/2012 10:44	0.456		0.509		0.8		2.4	JQ
LFKB-1	6/21/2012 8:16								
LFKB-1	7/19/2012 10:14	0.501		0.548		0.53		2	< MDL 2
LFKB-1	8/14/2012 15:25	0.911		0.967		1.07		2	< MDL 2
LFKB-1	8/16/2012 11:35								
LFKB-1	9/12/2012 15:41	0.563		0.612		0.27		2	< MDL 2
LFKB-1	10/10/2012 15:37	0.372		0.398		0.1	< MDL .1	2	< MDL 2
LFKB-1	11/14/2012 13:36	0.653		0.669		0.27		2	< MDL 2
LFKB-2	4/12/2012 9:17	0.072		0.098		0.53		2	< MDL 2, JQ
LFKB-2	5/3/2012 9:42	0.116		0.15		1.6		2	< MDL 2, JQ
LFKB-2	6/7/2012 9:13	0.206		0.226		4.27		2	< MDL 2
LFKB-2	6/20/2012 14:48								
LFKB-2	7/19/2012 9:10	0.29		0.323		1.34		2	< MDL 2
LFKB-2	8/14/2012 13:37	0.109		0.136		1.07		2	< MDL 2
LFKB-2	9/12/2012 14:07	0.243		0.283		0.1	< MDL .1	2	< MDL 2

STATION	VISIT_DATE	Phosphorus, Dissolved Reactive mg/l	DET_COND - Phosphorus, Dissolved Reactive mg/l	Phosphorus, Total mg/l	DET_COND - Phosphorus, Total mg/l	Chlorophyll a mg/m^3	DET_COND - Chlorophyll a mg/m^3	CBOD-5 mg/l	DET_COND - CBOD-5 mg/l
LFKB-2	10/10/2012 13:10	0.18		0.202		0.27		2	< MDL 2
LFKB-2	11/14/2012 11:48	0.438		0.455		0.53		2	< MDL 2
LFKB-8	4/16/2008 13:40	0.064		0.006	< MDL .006	1	< MDL 1	1	< MDL 1
LFKB-8	5/20/2008 13:16	0.058		0.086		1	< MDL 1	1	< MDL 1
LFKB-8	6/11/2008 15:58								
LFKB-8	6/25/2008 10:15	0.038		0.05		4.54		1	< MDL 1
LFKB-8	7/7/2008 11:12								
LFKB-8	7/16/2008 9:00								
LFKB-8	7/21/2008 9:00								
LFKB-8	7/23/2008 9:35	0.04		0.048		1.87		1	< MDL 1
LFKB-8	8/28/2008 9:15	0.073		0.173		1.07		1.2	JQ
LFKB-8	9/8/2008 9:10								
LFKB-8	9/17/2008 9:20	0.064		0.027		2.14		1	< MDL 1
LFKB-8	9/23/2008 9:35								
LFKB-8	9/25/2008 9:09								
LFKB-8	10/23/2008 9:45	0.069		0.058		1	< MDL 1	1	< MDL 1
LFKB-8	11/6/2008 9:45	0.082		0.041		1.07		1	< MDL 1
LFKB-8	4/11/2012 14:55	0.041		0.063		0.36		2	< MDL 2, JQ
LFKB-8	5/2/2012 14:16	0.058		0.087		2.85		2	< MDL 2, JQ
LFKB-8	6/6/2012 14:16	0.061		0.113		29.9		2	< MDL 2
LFKB-8	6/20/2012 11:43								
LFKB-8	7/18/2012 13:23	0.135		0.174		4.54		2	< MDL 2
LFKB-8	8/14/2012 11:55	0.103		0.186		1.6		2	< MDL 2
LFKB-8	9/12/2012 12:24	0.142		0.181		1.6		2	< MDL 2
LFKB-8	10/10/2012 11:26	0.117		0.143		1.6		2	< MDL 2
LFKB-8	11/14/2012 10:42	0.234		0.251		0.53		2	< MDL 2
LFKJ-2	4/16/2008 11:40	0.079		0.097		1	< MDL 1	1	< MDL 1
LFKJ-2	5/20/2008 12:15	0.061		0.109		1.6		1	< MDL 1
LFKJ-2	6/25/2008 11:45	0.033		0.044		9.34		1	< MDL 1
LFKJ-2	7/7/2008 12:10								
LFKJ-2	7/16/2008 9:45								
LFKJ-2	7/21/2008 9:45								
LFKJ-2	7/23/2008 10:30	0.052		0.06		7.74		1	
LFKJ-2	8/28/2008 10:00	0.075		0.187		2.14		1.1	JQ
LFKJ-2	9/8/2008 9:55								
LFKJ-2	9/17/2008 10:15	0.057		0.019		2.4		1	< MDL 1
LFKJ-2	9/23/2008 10:14								
LFKJ-2	9/25/2008 9:50								
LFKJ-2	10/23/2008 10:50	0.061		0.051		2.14		1	< MDL 1
LFKJ-2	11/6/2008 10:45	0.046		0.002	< MDL .002	1.87		1	< MDL 1
LFKJ-3	4/11/2012 13:31	0.023		0.042		2.14		2	< MDL 2, JQ

STATION	VISIT_DATE	Phosphorus, Dissolved Reactive mg/l	DET_COND - Phosphorus, Dissolved Reactive mg/l	Phosphorus, Total mg/l	DET_COND - Phosphorus, Total mg/l	Chlorophyll a mg/m^3	DET_COND - Chlorophyll a mg/m^3	CBOD-5 mg/l	DET_COND - CBOD-5 mg/l
LFKJ-3	5/2/2012 13:11	0.015		0.041		11.21		4.4	JQ
LFKJ-3	6/6/2012 13:00	0.024		0.054		12.1		2	< MDL 2
LFKJ-3	6/20/2012 7:43								
LFKJ-3	7/18/2012 12:34	0.093		0.128		10.15		2	< MDL 2
LFKJ-3	8/14/2012 10:33	0.077		0.117	JM	16.02		2	< MDL 2
LFKJ-3	9/12/2012 11:24	0.063		0.099		4.98		2	< MDL 2
LFKJ-3	10/10/2012 10:10	0.096		0.13		0.8		2	< MDL 2
LFKJ-3	11/14/2012 9:44	0.087		0.115		1.07		2	< MDL 2
LFKJ-5	4/24/2007 15:15	0.02		0.064		11.75	JH	2.6	
LFKJ-5	5/15/2007 16:43	0.018		0.075		30.44		2.1	
LFKJ-5	6/19/2007 15:57	0.004		0.063		43.25		1.5	
LFKJ-5	7/26/2007 9:28	0.019		0.067		38.45		1	< MDL 1
LFKJ-5	8/21/2007 16:19	0.007	JI	0.061		49.13	JH	1	< MDL 1
LFKJ-5	9/18/2007 15:17	0.035		0.058		1.07		1	< MDL 1
LFKJ-5	10/23/2007 16:51	0.03		0.056		24.56		1.9	
LFKJ-5	4/18/2012 12:25	0.017		0.049		4.27		2	< MDL 2
LFKJ-5	5/16/2012 12:46	0.027		0.064		3.74		2	< MDL 2
LFKJ-5	6/19/2012 10:42	0.005	JI	0.036		6.41		2	< MDL 2, JQ
LFKJ-5	7/25/2012 13:17	0.021		0.059		8.54		2	< MDL 2
LFKJ-5	8/21/2012 11:36	0.021		0.062		4.45		2	< MDL 2
LFKJ-5	9/19/2012 12:08	0.031		0.097		3.56		2	< MDL 2
LFKJ-5	10/16/2012 12:45	0.023		0.062		0.53		2	< MDL 2
LFKJ-6	6/29/2005 10:18	0.004		0.1	< MDL .1	23		1.7	
LFKJ-6	8/15/2005 10:00	0.005		0.1	< MDL .1	21.9	JH		Not Reported , F
LFKJ-6	10/18/2005 11:18	0.033		0.1	< MDL .1	78		0.5	
LFKJ-6	6/28/2006 10:40	0.006		0.102		98.7		2.8	
LFKJ-6	8/8/2006 11:20	0.004	< MDL .004	0.172		37.8		3.1	
LFKJ-6	10/12/2006 11:15	0.048		0.165		16.6		1.5	
LFKJ-6	6/13/2007 11:40	0.009		0.049		21.1		7.8	
LFKJ-6	8/9/2007 11:40	0.013		0.063		17.6		2.6	
LFKJ-6	10/10/2007 11:12	0.005	< MDL .005	0.013		26.2		1.7	
LFKJ-6	6/11/2008 11:00	0.006		0.041		38.4		5.1	
LFKJ-6	8/14/2008 10:10	0.03		0.066		13.4		1	< MDL 1
LFKJ-6	10/14/2008 10:40	0.038		0.086		9.08		1	< MDL 1
LFKJ-6	6/17/2009 12:15	0.048	JQ		Not Reported .01, RQ	5.34		1	< MDL 1
LFKJ-6	8/19/2009 11:35	0.008	< MDL .008, JQ		Not Reported .01, RQ	21.9		2.5	
LFKJ-6	10/21/2009 11:30	0.008	< MDL .008, JQ		Not Reported .01, RQ	1	< MDL 1	1	< MDL 1
LFKJ-6	5/5/2010 11:20	0.026	JQ		Not Reported .01, RQ	3.2		1	< MDL 1
LFKJ-6	7/7/2010 11:00	0.003	< MDL .003, JQ		Not Reported .01, RQ	25.6		1.5	JI
LFKJ-6	9/8/2010 10:45	0.003	< MDL .003, JQ		Not Reported .01, RQ	21.4		1.3	JI
LFKJ-6	5/19/2011 13:45	0.004	JI		Not Reported .01, RQ	27.77		2.3	

STATION	VISIT_DATE	Phosphorus, Dissolved Reactive mg/l	DET_COND - Phosphorus, Dissolved Reactive mg/l	Phosphorus, Total mg/l	DET_COND - Phosphorus, Total mg/l	Chlorophyll a mg/m^3	DET_COND - Chlorophyll a mg/m^3	CBOD-5 mg/l	DET_COND - CBOD-5 mg/l
LFKJ-6	7/21/2011 10:45	0.017	JQ		Not Reported .01, RQ	36.3	JH	2.2	
LFKJ-6	9/22/2011 11:30	0.02			Not Reported .01, RQ	1	< MDL 1	1	< MDL 1
LFKJ-6	4/18/2012 11:10	0.007	JI	0.05		25.63		2	< MDL 2
LFKJ-6	5/16/2012 11:26	0.075		0.116		0.1	< MDL .1	2.2	
LFKJ-6	6/19/2012 9:24	0.005	JI	0.055		15.49		2.3	JQ
LFKJ-6	7/25/2012 12:08	0.037		0.103		32.04		2	< MDL 2
LFKJ-6	8/21/2012 10:31	0.017		0.054		5.34		2	< MDL 2
LFKJ-6	9/19/2012 10:55	0.039		0.089		12.28		2	< MDL 2
LFKJ-6	10/16/2012 11:34	0.039		0.085		1.07		2	< MDL 2
LFKJ-6	11/29/2012 11:30	0.048		0.096	JQ4	3.2		2	< MDL 2
LFKJ-6	12/13/2012 11:20	0.074		0.096		2.14		2	< MDL 2
BANT-3	8/16/2005 16:30	0.004	< MDL .004	0.092		18.69	JH	2.2	
BANT-3	4/19/2006 11:25	0.017		0.048		21.63		3.8	
BANT-3	5/17/2006 11:41	0.006		0.041		4.27		1	< MDL 1
BANT-3	6/21/2006 11:33	0.004	< MDL .004	0.1	< MDL .1	12.3		1.4	
BANT-3	7/19/2006 11:13	0.004	< MDL .004	0.1	< MDL .1	41.1		1.7	
BANT-3	8/24/2006 12:16	0.004	< MDL .004	0.1	< MDL .1	40.9		2.1	
BANT-3	9/20/2006 11:46	0.01		0.056		48.59		1.4	
BANT-3	10/19/2006 12:35	0.04		0.087		10.68		2.1	
BANT-3	4/17/2007 16:01	0.013	JH	0.054		15.49		2.7	
BANT-3	5/15/2007 13:51	0.004	< MDL .004	0.039		13.88		2.6	
BANT-3	6/19/2007 15:49	0.005		0.036		30.44	JH	1.1	
BANT-3	7/25/2007 14:35	0.009		0.03		42.19		1	< MDL 1
BANT-3	8/21/2007 13:29	0.009	JI	0.055		18.16	JH	2	
BANT-3	9/18/2007 13:43	0.015		0.057		48.06		1	< MDL 1
BANT-3	10/23/2007 14:10	0.016		0.052		22.43		2.4	
BANT-3	8/12/2009 11:15	0.009	JI	0.053		24.56		2	< MDL 2
BANT-3	4/20/2011 11:22	0.025		0.045		2.67		2	< MDL 2
BANT-3	5/18/2011 14:06	0.006	JI	0.032		2.67		2	< MDL 2
BANT-3	6/23/2011 10:48	0.003	JI	0.026		15.13		2	< MDL 2
BANT-3	7/20/2011 11:00	0.004	JI	0.041		29.9		3.5	
BANT-3	8/24/2011 13:17	0.007	JI	0.036		25.63		2.8	
BANT-3	9/22/2011 10:53	0.02		0.112		3.56		2	< MDL 2
BANT-3	10/13/2011 11:45	0.008	JI	0.025		2.67		2	< MDL 2
BANT-3	4/18/2012 16:02	0.006	JI	0.031		11.75		2	< MDL 2
BANT-3	5/16/2012 15:11	0.013		0.047		6.94		3.4	
BANT-3	6/19/2012 14:19	0.005	< MDL .005	0.038		10.15		2	< MDL 2, JQ
BANT-3	7/25/2012 14:37	0.006	JI	0.046		38.72		2.7	
BANT-3	8/22/2012 15:18	0.01		0.041		21.36		2	< MDL 2
BANT-3	9/19/2012 15:20	0.028		0.06		9.08		2	< MDL 2
BANT-3	10/16/2012 14:22	0.02		0.047		7.83		2	< MDL 2

STATION	VISIT_DATE	Phosphorus, Dissolved Reactive mg/l	DET_COND - Phosphorus, Dissolved Reactive mg/l	Phosphorus, Total mg/l	DET_COND - Phosphorus, Total mg/l	Chlorophyll a mg/m^3	DET_COND - Chlorophyll a mg/m^3	CBOD-5 mg/l	DET_COND - CBOD-5 mg/l
VLGJ-5	6/29/2005 11:50	0.158		0.268		73.2		3.2	
VLGJ-5	8/15/2005 11:15	0.145		0.151		2.14	JH		Not Reported , F
VLGJ-5	10/18/2005 12:00	0.248		0.343		1	< MDL 1	0.3	
VLGJ-5	6/28/2006 9:38	0.326		0.348		47		0.8	
VLGJ-5	8/8/2006 10:30	0.193		0.275		11.7		1.6	
VLGJ-5	10/12/2006 10:00	0.175		0.235		19.2		2.3	
VLGJ-5	3/15/2007 11:25	0.222		0.248		8.81		3.8	
VLGJ-5	4/3/2007 11:30	0.351		0.395		2.94		1.2	
VLGJ-5	5/10/2007 11:25	0.278		0.453		1	< MDL 1	1.3	
VLGJ-5	6/13/2007 10:45	0.242		0.272		5.61		1.1	
VLGJ-5	7/10/2007 12:55	0.478		0.517		5.07		1	
VLGJ-5	8/9/2007 10:57	0.3		0.396		13.2		1.5	
VLGJ-5	9/4/2007 12:25	0.397		0.294	JH	12.3		2.4	
VLGJ-5	10/10/2007 10:20	0.275		0.205		15		1.6	
VLGJ-5	6/11/2008 10:25	0.164		0.199		6.41		1.2	
VLGJ-5	8/14/2008 9:30	0.176		0.237		24.6		1	< MDL 1
VLGJ-5	10/14/2008 9:55	0.253		0.243		4.27		1	< MDL 1
VLGJ-5	6/17/2009 11:20	0.083	JQ		Not Reported .01, RQ	9.61		1	< MDL 1
VLGJ-5	8/19/2009 10:50	0.194	JQ		Not Reported .01, RQ	4		1	< MDL 1
VLGJ-5	10/21/2009 10:45	0.016	JQ		Not Reported .01, RQ	1	< MDL 1	1	< MDL 1
VLGJ-5	5/5/2010 13:00	0.157	JQ		Not Reported .01, RQ	3.2		1	< MDL 1
VLGJ-5	7/7/2010 12:20	0.074	JQ		Not Reported .01, RQ	4.27		1	< MDL 1
VLGJ-5	9/8/2010 12:45	0.041	JQ		Not Reported .01, RQ	44.9		3.1	
VLGJ-5	5/19/2011 11:15	0.036			Not Reported .01, RQ	2.4		1	< MDL 1
VLGJ-5	7/21/2011 12:15	0.067	JQ		Not Reported .01, RQ	12.5	JH	2.8	
VLGJ-5	9/22/2011 13:00	0.075			Not Reported .01, RQ	6.41		1	< MDL 1
VLGJ-5	4/25/2012 10:00	0.127		0.152		1	< MDL 1	1	< MDL 1
VLGJ-5	5/23/2012 13:15	0.091		0.126	JQ	3.2		2	< MDL 2
VLGJ-5	6/25/2012 10:20	0.198		0.236		1.6		2	< MDL 2
VLGJ-5	7/18/2012 10:20	0.297		0.405		19.8		2	< MDL 2
VLGJ-5	8/30/2012 13:50	0.096		0.175		25.6		2	< MDL 2
VLGJ-5	9/27/2012 12:50	0.102		0.107		4.54		2	< MDL 2
VLGJ-5	10/24/2012 10:15	0.186	JQ4	0.207		1.6		2	< MDL 2
VLGJ-5	11/28/2012 10:45	0.231		0.249		1.6		2	< MDL 2
VLGJ-5	12/6/2012 10:00	0.231		0.252		2.49		2	< MDL 2

Code	Description
F	An unforeseeable equipment failure occurred during the laboratory analysis for this parameter.
JB	The identification of the analyte is acceptable; the reported value is an estimate. Sample was not diluted; reported result is beyond (higher) the highest standard on the calibration curve
JH	The identification ofthe analyte is acceptable; the reported value is an estimate. The analytical holding times for analysis are exceeded. Micro: Reported microbiological result is an estimate. The analytical holding time for analysis was exceeded.
JI	The identification of the analyte is acceptable; the reported value is an estimate. The reported value is between the method detection limit and the practical Quantitation limit.
JM	The identification of the analyte is acceptable; the reported value is an estimate. The sample matrix interference precludes accurate determination.
JQ	The identification of the analyte is acceptable; the reported value is an estimate. The reported value failed to meet established QC criteria.
JQ1	The identification of the analyte is acceptable; the reported value is an estimate. Laboratory Control Sample (LCS) / Laboratory Fortified Blank (LFB) recovery is outside control limits.
JQ4	The identification of the analyte is acceptable; the reported value is an estimate. Matrix spike recovery is outside control limits
JQ6	The identification ofthe analyte is acceptable; the reported value is an estimate. Spurious contamination or reagent contamination is evident at a level that affects accuracy
RQ	The presence or absence ofthe analyte can not be determined from the data due to quality control problems. The reported value failed to meet established QC criteria.

Appendix B

Bankhead and Locust Fork 72hr Diurnal Study August 2016

During the month of August in 2016, the Department conducted a 72 hour diurnal study to continuously monitor instream water quality conditions at several stations in the Bankhead Reservoir and also the Locust Fork tributary embayment. Datasondes were deployed at each station at a depth of five feet and programmed to collect water quality data on a 15 minute time interval. The results of the study illustrate eutrophic conditions at both Locust Fork tributary embayment stations (BANT-3 and LFKJ-6), as indicated by the supersaturated dissolved oxygen concentrations and also pH levels elevated above criteria values. The healthy instream water quality conditions at station BANT-4, located in the main river channel of the Mulberry Fork just upstream of the confluence with the Locust Fork, serve as a guideline for comparison. Reference Figure 6.1.1 Bankhead Lake and major tributaries for a map depicting the locations of the stations included in the study.

Figure B-1 Bankhead and Locust Fork Diurnal Study August 2016 - Dissolved Oxygen Results

Figure B-2 Bankhead and Locust Fork Diurnal Study August 2016 – ODO % Saturation Results

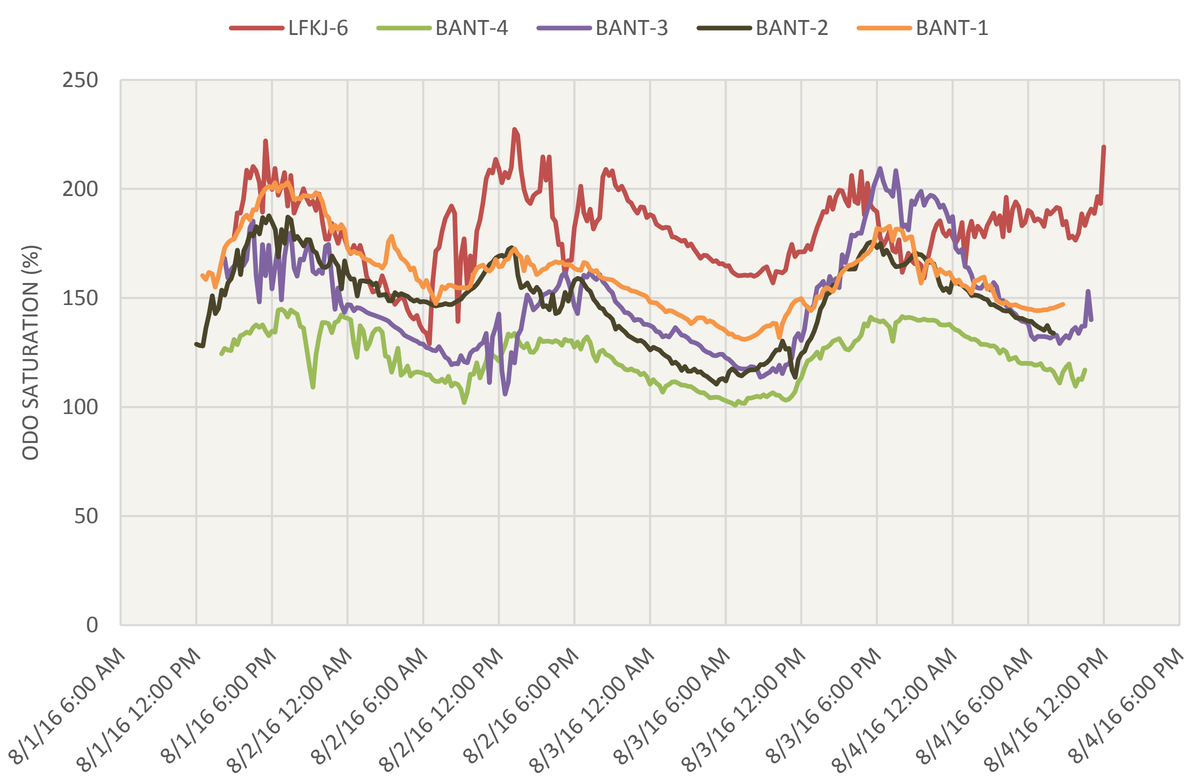


Figure B-3 Bankhead and Locust Fork Diurnal Study August 2016 – Temperature Results

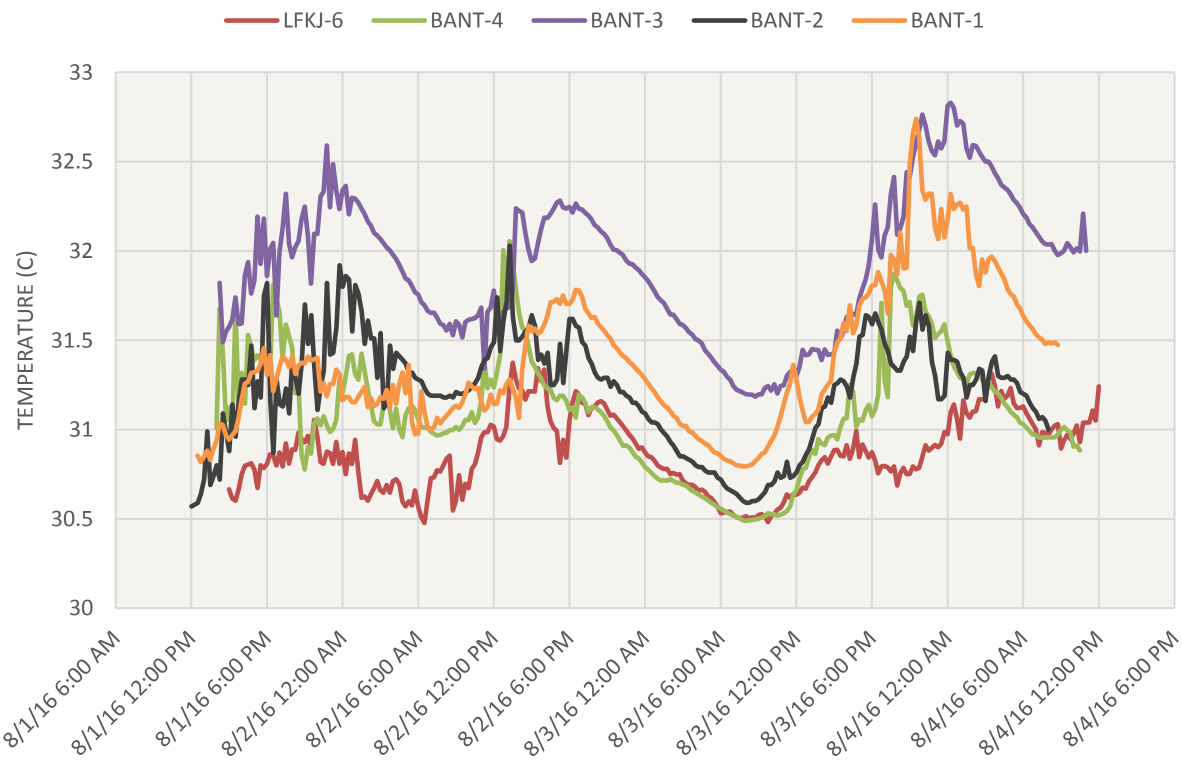
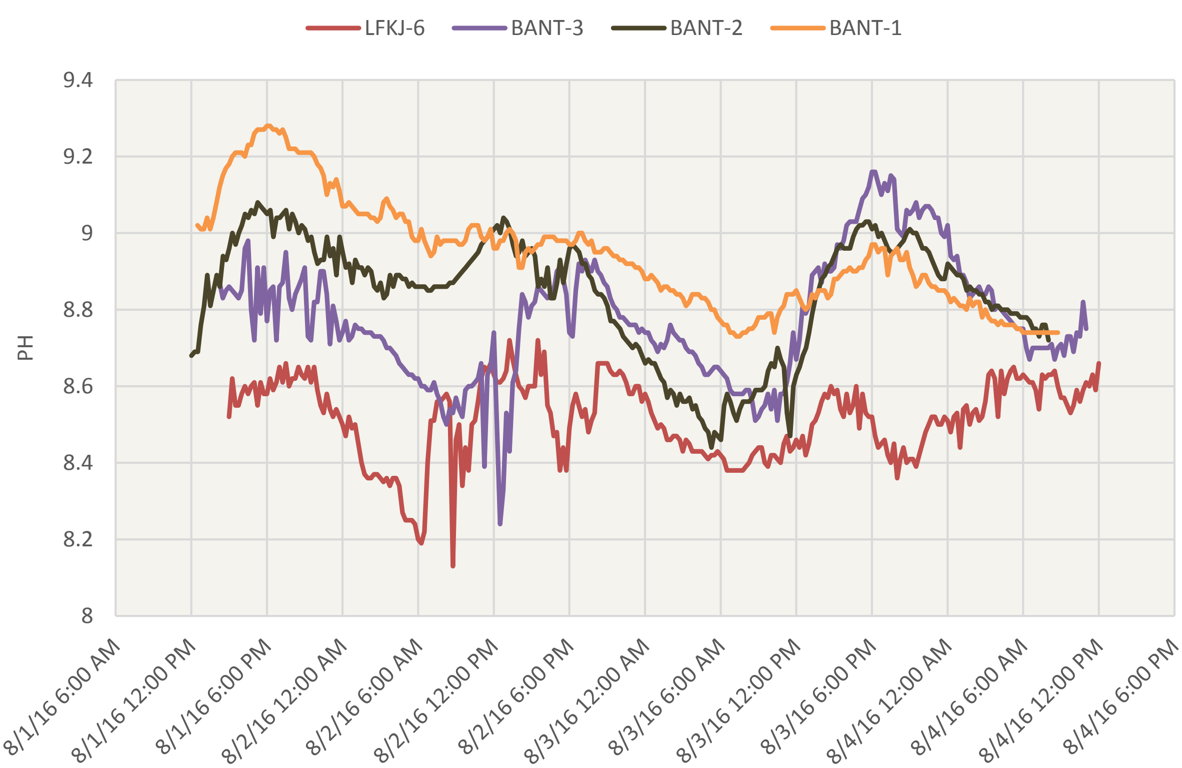


Figure B-4 Bankhead and Locust Fork Diurnal Study August 2016 – pH Results



Appendix C

Locust Fork and Village Creek Station Pictures

Figure C.1 Locust Fork Station LFKB-15 (8/16/2012)

Figure C.2 Locust Fork Station LFKB-1 (8/16/2012)

Figure C.3 Locust Fork Station LFKB-2 (6/20/2012)

Figure C.4 Locust Fork Station LFKB-8 (6/20/2012)

Figure C.5 Locust Fork Station LFKJ-3 (6/20/2012)

Figure C.6 Locust Fork Station LFKJ-6 (4/10/2013)

Figure C.7 Locust Fork Station BANT-3 (8/4/2016)

Figure C.8 Village Creek Station VLGJ-5 (7/18/2012)